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Volume 29 OCTOBER, 1922 Number 2

MACHINERY

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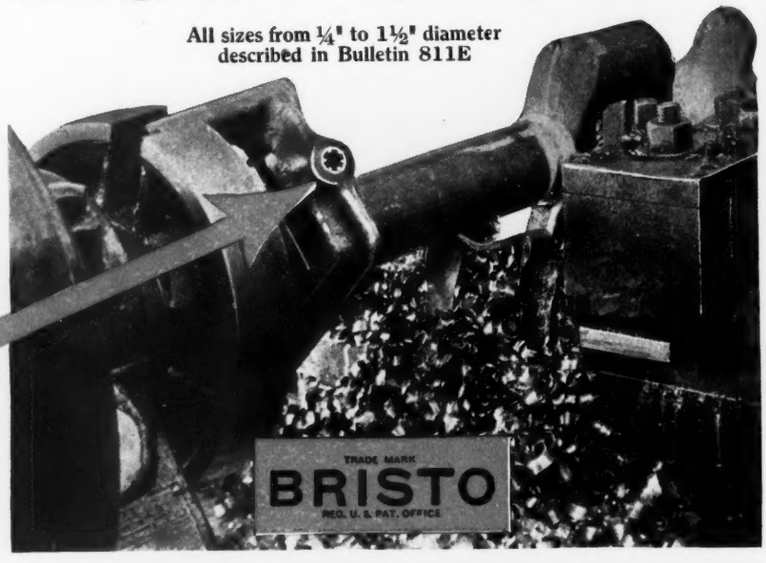

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VOLUME 29 **MACHINERY** NUMBER 2

OCTOBER, 1922

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CIRCULATION FOR SEPTEMBER, 1922, 19,000 COPIES

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November MACHINERY will contain an original analysis of chain and sprocket action, showing that low numbers of teeth and incorrect center distances cause appreciable variations in angular velocity and a reduction in the efficiency of the chain drive, by G. M. Bartlett, chief engineer of the Diamond Chain & Manufacturing Company

Published monthly. Yearly subscription in United States and territories, Philippines, Porto Rico, Canal Zone, Cuba, Mexico and Shanghai, $3; Canada, $4; foreign countries, $6; single copies 35 cents, postage extra. The receipt of a subscription is acknowledged by sending the current number. Checks and money orders should be made payable to THE INDUSTRIAL PRESS.

Copyright 1922 by THE INDUSTRIAL PRESS. Entered as second-class mail matter, September, 1894, at the Post Office in New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A. It is understood that all contributed articles are submitted exclusively to MACHINERY; when accepted and published, payment is made at our regular space rates.

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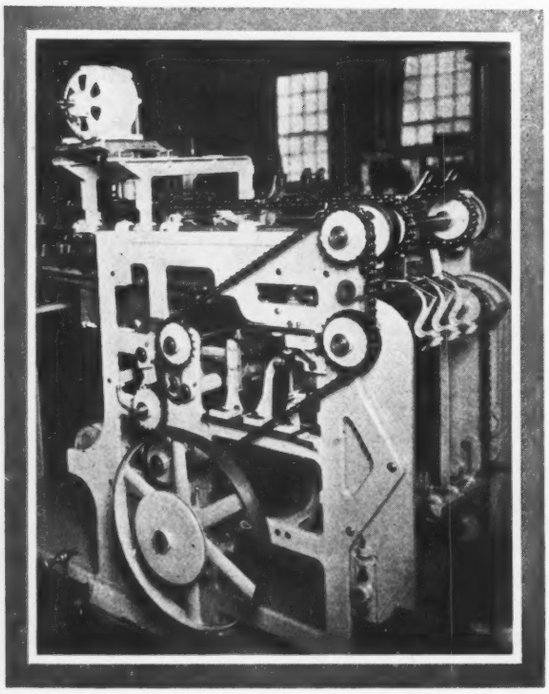
The Transmis



Current

October MACHINERY, first of two Transmission and Conveying numbers, features editorial articles of interest to all MACHINERY'S readers—for all use and transmit power; all convey raw and finished products.

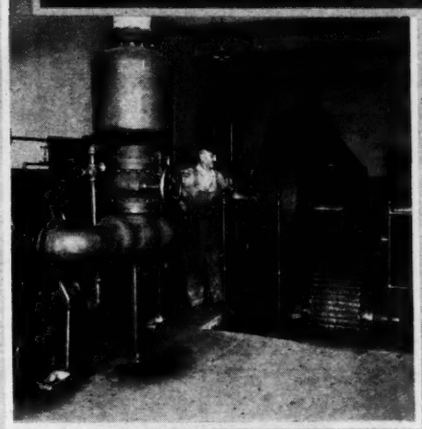
"Assembling by Conveyor" describes a system of assembling that is now being introduced into many plants. The attitude of workers toward labor-saving machinery of this type is discussed, and methods of assembling large as well as small work are shown.

"Mechanical Transmission of Power" is a review of the various means for power transmission, belting, chain drives and gearing. Two other Transmission articles, cover "Babbitt Bearing Metal" and "The Design and Application of Flexible Couplings."

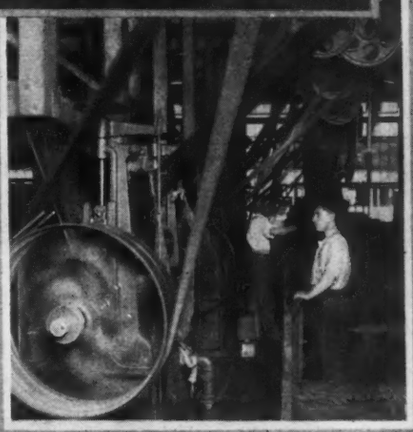
An advertising section devoted entirely to Transmission and Conveying Equipment is a feature of this number; also the new Special Equipment Section, grouping the advertisements of special tools, machines, etc., which beginning with October becomes a permanent feature of MACHINERY.

MACHINERY for

Mechanical Transmission of Power



By FORREST E. CARDULLO
Chief Engineer,
The G. A. Gray Co.,
Cincinnati, Ohio
and
FRANKLIN D. JONES
Associate Editor of MACHINERY



MACHINE designers are confronted continually with problems relating to the transmission of power and means of obtaining mechanically certain velocities or movements. The selection of an improved method of transmitting motion and a given amount of energy may be governed entirely by fixed conditions, but frequently the designer finds it possible to use different methods, and then it is essential to weigh carefully the relative advantages. This general review of power-transmitting appliances is intended to feature the more important points relating to the application of different systems of transmission and include designing data applicable to common transmission problems.

Factors Governing the Selection of Transmissions

At the outset some of the factors influencing the selection of different forms of transmissions will be considered. The important factors are (1) kind of motion; (2) relative positions of driving and driven members; (3) velocities of driving and driven parts; (4) amount of power to be transmitted, and efficiency considered essential; (5) importance of quiet operation; and (6) possible effect of foreign matter or moisture upon operating conditions or life of drive. The order in which these different factors are given does not necessarily indicate their relative importance, since this varies with different classes of mechanisms.

Considering first the kind of motion, designers are concerned chiefly with rotating parts. The rotation may be either uniform, varying, or intermittent. The speed of rotation may, of course, be slow, medium, or fast. Provision for changing the velocity ratio may be required, as in the case of the change-gearing of lathes. Exactness of the velocity ratio may or may not be required, and this is a matter which may fix the type of transmission. Sometimes an oscillating motion is necessary, one or more members swinging through an arc instead of making complete turns. Besides rotary motion, straight-line motion is frequent in the design of machine tools. Helical movements and even movements in an irregular line are sometimes necessary for certain types of work. A helical motion is required in order to give a cutting tool a uniform feed and rotary motion, while wire bending and knotting devices require movements in an irregular line.

The type of transmission would not ordinarily be selected by considering merely the kind of motion. For instance, shafts having practically uniform rotary motion might be driven either by gearing or by some type of belt transmission, depending upon other conditions. The relative positions of driving and driven members largely govern the selection. For instance, if parallel shafts are located quite close to each other, spur gears or herringbone gears are ordinarily used; on the other hand, if the center distance is relatively large, some kind of belt or chain drive is preferable under average conditions. If we assume, however, that a decided reduction in speed were required for a driven shaft, even though located some distance from the driver, then possibly a combination of worm-gearing with a connecting shaft would be used instead of the belt drive, although usually a combination of belt drive and reduction gearing would be employed.

The amount of power to be transmitted may or may not be of importance in designing a drive. Frequently the problem is confined to transmitting a certain motion, possibly with given requirements as to speed or velocity changes, but without considering the amount of power, assuming that the latter is so small as to be negligible. On the other hand, there are many transmissions designed

This review of mechanical means for transmitting power is intended to supplement the more special treatises previously published, the plan being to present, in condensed form, a broad view of this general subject. Important factors governing the selection of various standard devices for transmitting power mechanically are considered, in conjunction with methods of determining power-transmitting capacities. This article relates to the design and installation of shafting and belt and chain transmissions. The second installment, in the November number, will deal exclusively with power transmission problems that are met with in the application of various types of gearing.

primarily as power transmitters, and in these strength, efficiency, and durability are paramount. Existence of large amounts of foreign matter, such as dust, may affect the selection of a drive in some cases, but ordinarily the type of drive depends upon other conditions, since it is usually practicable to protect a transmission from injurious foreign matter by means of a casing or enclosure.

Quiet operation is very important with some transmissions, whereas with others noise is tolerated to permit using inexpensive equipment. For instance, some chain drives of the cheaper grades are comparatively noisy in operation, but are preferable for certain classes of service to the better grades of chain transmissions.

Having summarized the essential factors affecting the selection of transmissions, the more important features of different classes of drives will be dealt with as concisely as possible.

Shafting for Power Transmission

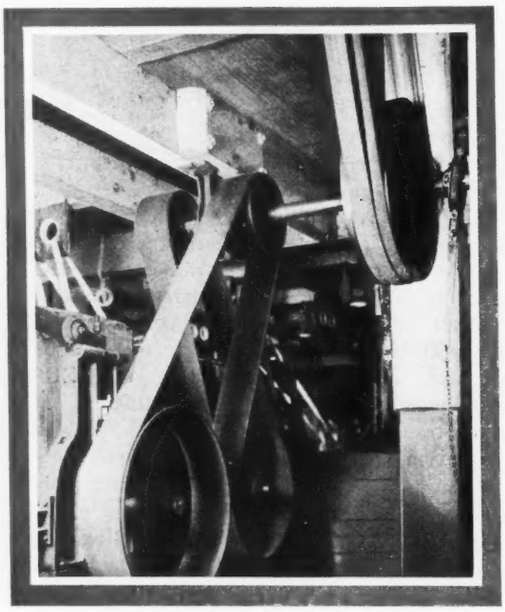
Since shafting is applied in various ways for transmitting power, either to support and drive pulleys, sprockets, gears, etc., or as a direct means of transmission, some of the points relating to the installation of shafting will be considered before gearing or belt transmissions are dealt with. In determining the size of shafting for a given installation, it is essential to consider whether the stresses are to be largely torsional, bending, or a combination of torsional and bending stresses. The torsional strength and the resistance to bending is proportional to the cube of the diameter. The following simple formulas are in common use for determining readily the size and approximate power-transmitting capacity of shafting:

$$D = \sqrt[3]{\frac{H \times F}{R}} \quad \text{or} \quad H = \frac{D^3 \times R}{F}$$

In these formulas,

D = shafting diameter in inches;

H = horsepower to be transmitted, or power that the shaft will transmit;



Belting not only provides a simple efficient means of transmitting power, but also serves to protect many driven machines against injurious stresses, as excessive overloads cause slippage.

R = revolutions per minute; and

F = a factor that varies according to the class of shafting or stresses considered allowable.

When these formulas are applied to the main shafts for power transmission with bearings located, say, 8 feet apart, F may have a value of 80, assuming that the speed is not excessive and the loads are steady. For ordinary lineshafting for medium and light service, subjected almost entirely to torsional stresses, F may be reduced to 50. For countershafts or other relatively short shafts, F may be further reduced to 25 or 35. For a "head shaft," or one carrying the receiving pulley, F should equal 100 or possibly 125. This head shaft, incidentally, is connected to the smaller lineshafting by a reducing coupling, and it should be supported by bearings close to the main or receiving pulley.

Determining Sizes of Shafts Subjected to Bending and Torsional Stresses

When shafting is subjected to transverse loading so that it must resist severe bending, as well as torsional stresses, this combination of stresses should be taken into account in calculating the size of the shaft. According to the experience of at least one large manufacturer of power transmission apparatus broken shafts are frequently the result of disregarding the bending stresses in connection with drives having pulleys, gears, etc., located so far from the bearings as to impose upon the shaft a large transverse load.

In determining the diameter of a shaft that must withstand combined torsional and bending stresses, either an equivalent bending moment or torque is first computed, which produces a stress equivalent to the maximum stress produced by the combined moments.

Let:

D = shaft diameter, in inches;

T_e = equivalent torque or twisting moment in inch-pounds;

M_e = equivalent bending moment, in inch-pounds;

T = actual twisting moment;

M = actual bending moment;

S = allowable working stress in shear;

F = allowable tensile stress;

Z_b = ordinary sectional modulus; and

Z_p = polar sectional modulus, which is twice the ordinary sectional modulus.

Then we will have the following equations:

$$M_e = \tfrac{1}{2}\ (M + \sqrt{M^2 + T^2}) = FZ_b$$

$$T_e = M + \sqrt{M^2 + T^2} = SZ_p$$

Since the polar sectional modulus of a circular shaft equals $0.196\ D^3$; and the ordinary sectional modulus equals $0.098\ D^3$ we have the following:

$$D = \sqrt[3]{\frac{10.2\ M_e}{F}} \qquad D = \sqrt[3]{\frac{5.1\ T_e}{S}}$$

That formula which gives the highest value for D should be used, the shaft diameter being based upon whichever moment (bending or twisting) is large enough to be the controlling factor. The allowable shearing stress should equal about four-fifths of the permissible stress in tension.

Distance Between Shaft Bearings

Bearings for lineshafts operating under ordinary conditions are usually located from 6 to 10 feet apart, 8 feet being a fair average, but the distance should be determined with reference to the class of service and the speed of the shafting. According to common practice, the deflection of the shaft should not exceed 0.010 inch per foot of length, and the bearings should be placed close enough to each other to prevent centrifugal whirling action. A rule which has been applied for bare shafting is as follows:

To determine the distance between the bearings in feet, multiply 720 by the square of the shaft diameter, in inches, and extract the cube root of the product. For shafts carrying pulleys, etc., this rule is modified and shorter distances obtained by using the constant 140 instead of 720.

Three empirical formulas deduced by B. D. Pinkney, take into account the speed or effect of centrifugal force when applied to three classes of shafting. If

L = distance between bearings, in feet;

N = revolutions per minute;

D = shaft diameter, in inches; and

C = a constant depending upon the class of service,

$$L = C \times \left(\frac{1500}{N + 1500}\right) D^{2/3}$$

For head shafts or those to which power is applied, and also for shafts which must resist the bending action of pulleys, gears, etc., and which may be reversed under full load, $C = 5$; for ordinary lineshafts (except that section to which power is applied) and also for countershafts not reversible under full load, but having ample allowance for bending stresses from pulleys, etc., $C = 6.5$; for shafts and countershafts which merely transmit power and which have all the pulleys or the gearing located close to the bearings so that bending stresses may be considered to be negligible, $C = 9.5$.

The preceding formula and the different constants are based upon a maximum deflection of 0.010 inch per foot of length and were verified by an extensive series of tests. If the bearings used are of the rigid type, L equals the distance between the adjacent ends of the bearings, whereas for self-aligning bearings, L equals the center-to-center distance.

The speeds of lineshafting usually vary from 110 to 150 revolutions per minute for ordinary machine shop drives, although for high-speed machinery, such as grinders, the lineshaft speed may be increased to possibly 300 revolutions per minute. Lineshafting in woodworking shops usually runs at a speed of from 200 to 250 revolutions per minute.

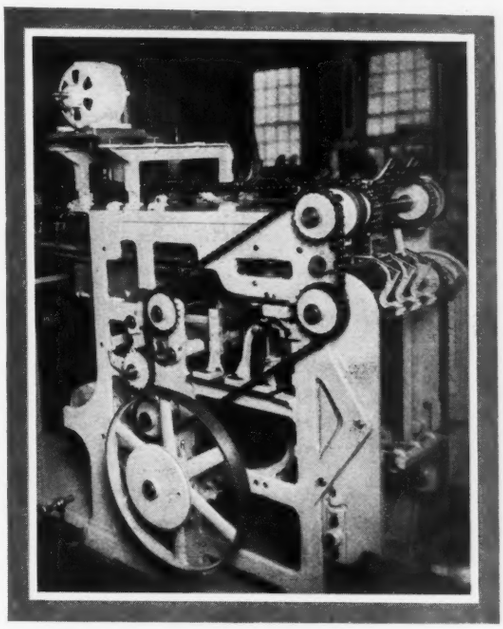
Torsional Deflection of Shafts

A shaft subjected to ordinary service should be so proportioned that it cannot be twisted through a greater angle than about 0.08 degree per foot of length. When torsional deflection must be considered in the case of certain long shafts the following formula may be used in which

D = shaft diameter in inches;
C = a constant; and
T = torsional moment in inch-pounds.

$$D = C \times \sqrt[3]{T}$$

When shafts are for heavy loads and are to be reversed under full load, $C = 0.33$. For ordinary service, and when shafting is not to be reversed under full load, $C = 0.30$, and for light service with only gradual load fluctuations, $C = 0.28$.



Chain drives are positive and compact; and, in addition to general application for power transmission often enable designers of complicated machinery to transmit motion readily between various shafts.

Standard Sizes for Shafting

In order to reduce the fifty or sixty sizes of shafting now listed by the trade, to the relatively small number of sizes commonly used, the following list of diameters has been recommended as standard by the American Society of Mechanical Engineers and will doubtless be adopted in the near future:

Transmission Shafting—15/16, 1 3/16, 1 7/16, 1 11/16, 1 15/16, 2 3/16, 2 7/16, 2 15/16, 3 7/16, 3 15/16, 4 7/16, 4 15/16, 5 7/16, and 5 15/16 inches.

Machinery Shafting—Size intervals extending to 2½ inches by sixteenth inches; from 2½ to 4 inches inclusive, by eighth inches; and from 4 to 6 inches by quarter inches.

Couplings for Connecting Power-transmitting Shafts

The function of some couplings is merely to join the ends of shaft sections rigidly so that in effect two or more sections form one continuous line of shafting. A second type of coupling or clutch is designed to allow one shaft section to be connected or disconnected at will. A third type known as a universal joint, allows considerable variation in angular position of the driving and driven shafts, and a fourth type designated as a flexible coupling, provides for lack of alignment between the driving and driven shafts, due either to bearing wear or original errors in alignment. Couplings of the latter class also provide a certain amount of elasticity or cushioning effect, thus avoiding shocks due to sudden starting.

Since these various classes of couplings are made in a great variety of designs, it would not be feasible to enter into details regarding the numerous forms in use, but elsewhere in this number will be found an article covering certain essential features relating to flexible couplings. Couplings of various kinds are ordinarily purchased from manufacturers, so that the average designer is more concerned with problems relating to transmissions of the belting or gearing types.

Transmission of Power by Belting

Power ratings for belt drives vary considerably, according to different authorities and investigators, even for belts of the same kind and applied under similar conditions, as will be seen by a comparison of the conclusions found in text-books, articles, and the literature published by belt manufacturers.

The general formula for determining the power rating follows:

$$H = \frac{SVW}{33{,}000}$$

In this formula,

H = horsepower;
S = effective belt pull, in pounds per inch of width;
V = belt velocity, in feet per minute; and
W = belt width, in inches.

The effective pull or difference between the tensions on the tight and slack sides is the variable factor. This factor is affected by belt velocity and arc of pulley contact, as well as by belt thickness and its relation to the pulley diameter. It is evident that the kind and quality of the belting must be taken into account in determining the allowable working load, but even for the same belt quality, wide differences of opinion exist as to the amount of pull per unit of width or area that is conducive to the best results when initial cost, durability, and everything pertaining to it are allowed for.

Obviously, if the working load is excessive, the life of belting will be reduced accordingly and the load on the bearings increased. On the other hand, if belts are given too low a rating, this means that wider and more expensive belts will be installed than is necessary. Somewhere between these extremes is the most economical rating, which is based not only upon the initial cost of the belt but also upon all subsequent costs connected with that particular installation. For instance, if a belt is subjected to such severe stresses that frequent delays for repairs are necessary, losses incident to these delays in manufacturing plants, may indicate that larger and more expensive belting would have been justified. The conditions under which a belt operates may also be of importance in this connection, as, for example, when a belt is frequently started and in starting must pick up a heavy load suddenly. In this case the rating should be relatively low to allow for the overload. It

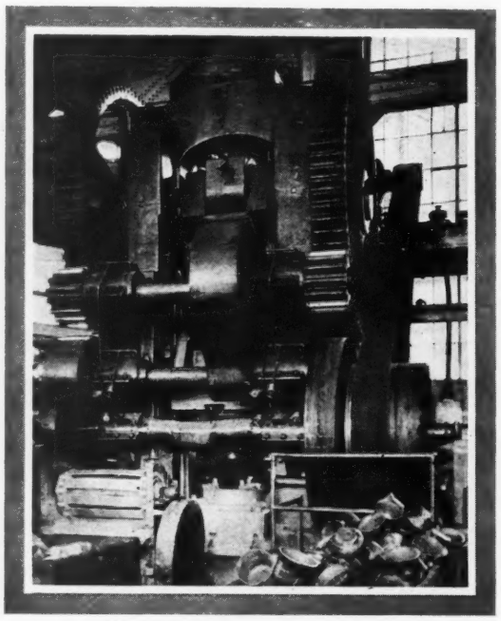
is evident that higher working stresses may be allowed for the better grades of belting, so that it is impracticable to specify working stresses unless they are related to belting of known quality.

More specific information on this subject will be found in the article entitled "Power Transmission by Belting," published in June MACHINERY, beginning on page 814. The method of determining belt ratings, as fully explained in this article, evidently conforms quite closely with the general recommendations of belting manufacturers. Another article entitled "Charts for Determining Belt Widths," which appeared in March MACHINERY (beginning on page 562) gives much lower power ratings, the theory being that these relatively low working tensions are conducive to economy when all the different factors have been taken into consideration.

Relation of Pulleys to Belt Drives

The type of pulley used for a belt drive is another factor affecting the power-transmitting capacity. For instance, tests have shown that steel pulleys have better gripping power than cast-iron pulleys, and the capacity of both steel and cast-iron pulleys can be increased by means of cork inserts in the rim which are applied to some pulleys that require an unusually high coefficient of friction. Covers of leather or rubber are also used in connection with some cast-iron pulleys to increase the pulling power. Wood pulleys have a much higher coefficient of friction than plain cast-iron pulleys for a normal percentage of belt slip, and all three types of pulleys mentioned have been used extensively and have been found to give satisfactory service under proper working conditions.

As a general rule, pulley diameters should be as large as other conditions will permit, one limiting factor being the belt velocity, which ordinarily should not exceed 4500 or possibly 4800 feet per minute. Information as to maximum speeds should preferably be obtained from the manufacturer of whatever type of pulley is to be used. Cast-iron pulleys are usually limited to a rim speed of 3000 feet per minute, unless special precautions have been taken regarding balance, and then the limit is generally 5000 feet per minute. Split cast-iron pulleys formed of two sections should be limited to 55 or 60 per cent of the speed of solid pulleys. Steel pulleys, which combine lightness with strength, are usually limited to about 6000 feet per minute for the common split type, and much higher speeds are allowed for the whole steel pulleys which are intended for unusual conditions as regards velocity. The maximum safe speeds for wood pulleys vary considerably for different types, manufacturers' recommendations ranging from 5000 up to 10,000 feet per minute, the latter speed applying to pulleys of special construction.



The universal need of positive drives in practically all mechanisms has focussed the attention of engineers for generations upon the development of gears adapted for different classes of service.

Chain Transmissions

Chain drives are especially applicable when the distance between the driving and driven shafts is too long for gearing and too short for belting, although this general statement does not apply under all conditions. Chain drives, however, are generally substituted for belting when the driving and driven shafts are comparatively close, and if correctly installed, the chain type of transmission is more durable than belting. It is also positive in action, compact, and without the initial tension required for a belt drive. A uniform turning movement is also obtained. While the initial cost of the chain drive is higher, this is warranted for many classes of service.

Several forms or types of chains have been developed for power transmission. The block chain, consisting of steel blocks connected by side links or plates is adapted for light machine drives, and the double width or twin type is used when the amount of power to be transmitted is relatively high. Roller chains differ from block chains in that rollers and bushings are inserted between the links instead of solid blocks. Roller chains are stronger than block chains, and are used in preference to the latter when the speeds and amount of power to be transmitted are comparatively high. Bushing chains resemble roller chains somewhat, but differ from the latter in that the bushings between the side links are not provided with rollers; they are adapted for transmitting considerable power at relatively low speeds. Silent chains provide a positive, durable, and efficient drive, especially where considerable power is to be transmitted.

Power Transmitted by Chain Drives

The amount of power that a given chain will transmit varies according to the speed and allowable pull or chain load. The working load for roller chains should not exceed 1/10 of the ultimate tensile strength of the chain, and it may be limited to 1/30 or 1/40 of the ultimate strength, particularly if the loads are to be applied suddenly. The working load varies according to the amount of rivet bearing surface, the suddenness of the load, the speed of the driving sprocket, the quality of the chain, and the care it receives as regards lubrication. According to the Diamond Chain & Mfg. Co., the chain pull should not, as a general rule, exceed 1000 pounds per square inch of projected rivet area, although a slow-speed transmission may operate satisfactorily with a chain pull of 2000 or even 3000 pounds per square inch of projected rivet area.

When the allowable working load is known, the amount of horsepower transmitted by chain drive may be determined by the following formula:

$$H = \frac{LV}{33{,}000}$$

where

H = horsepower;

L = allowable pull or working load, in pounds; and

V = velocity of chain, in feet per minute.

Assume that the capacity of a roller chain is required, and that the projected rivet area is 0.72 square inch. The speed is to be 800 feet per minute, and 1500 pounds per square inch of projected rivet area is to be allowed. Then

$$H = \frac{1500 \times 0.72 \times 800}{33{,}000} = 26$$

For determining the load to which a chain is subjected with a given horsepower and speed, the formula is:

$$L = \frac{33{,}000 \times H}{V}$$

The minimum diameter for a sprocket shaft made of mild steel (according to the Diamond Chain & Mfg. Co.) should equal three times the cube root of the quotient obtained by dividing the horsepower by the revolutions per minute of the sprocket, assuming that the shaft is subjected to torsional stresses only. For torsional and bending stresses multiply this result by about 1.5.

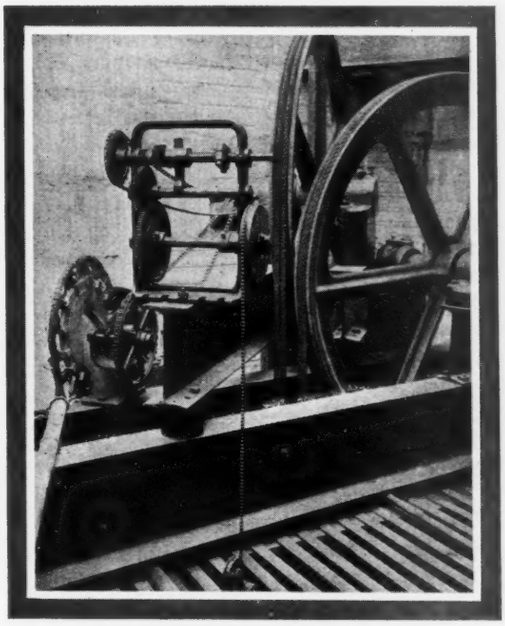
In determining the pitch of a chain, the maximum speed of the smaller sprocket should be considered. A higher sprocket speed is allowable with a chain of short pitch than with one of long pitch. Speeds of 1000 to 1200 feet per minute are often recommended for roller chains, and 700 to 800 feet per minute for block chains; but if the conditions regarding sprocket speed and chain pull are favorable, these maximum speeds may be increased considerably. It has been demonstrated that chain speed alone has little to do with the destructive action between the chain and the sprocket, but high sprocket speed combined with long pitch is destructive and noisy because of the impact between the chain link and the sprocket as the roller seats itself. If P = maximum allowable pitch of chain and S = maximum allowable speed of sprocket in revolutions per minute, the following approximate formulas may be used to determine the values of P and S:

$$P = \left(\frac{900}{S}\right)^{2/3} \qquad S = \frac{900}{\sqrt{P^3}}$$

The capacity of chain drives should not be based on the ultimate strength of the chain exclusively, but rather upon working loads which are related to the durability of the transmission. This accounts for the fact that the bearing area of pins and bushings is taken as a basis. Some manufacturers of silent chains limit the working load to 650 pounds per square inch of projected pin area to minimize wear and insure maintaining an efficient drive.

An extensive and carefully conducted series of tests made by the Link-Belt Co. showed that the working load on Ewart detachable link belt should be obtained by dividing the ultimate strength by a factor varying according to the speed, as follows: For a velocity of 200 feet per minute, divide the average ultimate strength by 6; for a velocity of 300, divide by 8; for 400, divide by 10; for 500, divide by 12; for 600, divide by 16; and for 700, divide by 20.

Transmissions are made in such a large variety of designs that it is not possible to give a general formula for determining the power-transmitting capacity, owing to the variable factors involved, but information of this kind may be obtained directly from the manufacturer of whatever type of chain is to be installed.



Ropes made of steel wire are indispensable for hoisting, conveying, and similar applications, while fiber rope drives provide an efficient, quiet and fairly positive means of power transmission.

Bearings as Related to Transmission Efficiency

As the mechanical efficiency of a transmission may be affected decidedly by the bearings used, numerous experiments have been made for reducing frictional losses and insuring durable bearings which are safeguarded against defective operation. Losses in a single bearing may appear insignificant, but when this loss is multiplied by the number of bearings required for many complete transmissions, the total waste is often of considerable magnitude. These bearing losses also continue indefinitely, so that an initial expense for bearings that minimize such waste may be negligible, when compared with the ultimate saving. In addition to waste through friction, losses due to bearing troubles and repair costs may be factors of great importance.

In connection with plain bearings, alloys for various kinds of service are available, as well as adequate lubricants and lubricating systems. Oilless bearings represent another development which meets certain bearing requirements. While ball and roller bearings are used extensively, they will doubtless be applied in the future to many classes of machinery now equipped with bearings of the sliding type. Since friction means waste, the reduction of friction in every way practicable has always been an important problem for mechanical engineers. Manufacturers of anti-friction bearings have perfected types that meet a wide range of operating conditions. Such bearings not only reduce frictional losses to a minimum, but also may be arranged to run satisfactorily for long periods with little or no attention. These developments have not been utilized by engineers as fully as is warranted by economical practice, although the application of ball and roller bearings is increasing continually.

In past numbers of MACHINERY various important details concerning the design and application of both plain and anti-friction bearings have been dealt with, so this subject will not be considered further at the present time. The next and concluding installment of this article, which will appear in the November number, will deal with the power-transmitting capacities of various classes of gearing.

* * *

It is stated in a recent issue of *Engineering* that the Technical Commission of the Royal Dutch Aero Club has offered a prize of 3000 guilders (about $1200, present exchange) for the best instrument or set of instruments which will indicate to the pilot of the airplane, flying in dense fog, his height from the ground or water. The indication must be independent of any installation on the ground or water, and also of the atmospheric pressure, and the error of indication must not be greater than 10 per cent for heights up to approximately 1000 feet. The competition is open to persons of all nationalities, and drawings and descriptive matter must reach the awarding jury at the offices of the Royal Dutch Aero Club Heerengracht 13, The Hague, Holland, not later than March 15, 1923.

* * *

THE SWEDISH MACHINE INDUSTRIES

There has been little or no improvement in the Swedish machinery and electrical industries during 1922. While in September, 1920, these industries employed 60 000 workers, only about 25,000 were employed this spring. Wage reductions of about 40 per cent have been made as compared with 1920 wages. The only orders of any account that the industry has at present are those from Russia. The most serious conditions exist in the machine tool, the woodworking machinery, and the agricultural machinery industries. German competition, which for a couple of years was very serious is now less formidable, as German prices have reached the level of the world's markets; the difficulties experienced in regard to deliveries from Germany are also tending to check German imports.

Ball Bearings in Textile Mills

By HOWARD N. PASCOE, Electrical Engineer, Fafnir Bearing Co., New Britain, Conn.

IN the following are recorded the results obtained in three tests made to determine the power-saving possibilities of ball-bearing hanger boxes. In each test the shafting was driven by a 220-volt motor, and the power consumption was recorded with the original installation of plain bearings and with Fafnir ball bearings. The records were made on an Esterline graphic wattmeter, which indicated the power input for both sets of bearings for each test. The purpose of the tests was to show the power consumption using both types of bearings under as nearly identical operating conditions as possible, and to demonstrate the saving resulting from the use of ball bearings. The saving will vary for different localities and under different operating conditions. Where the cost of electric energy is higher, the saving in dollars and cents will be greater, as this varies as much as two or three cents per kilowatt-hour.

The first test was made at the mill of Follmer, Clogg & Co., Lancaster, Pa. Sixty feet of lineshafting, originally hung in three 2 15/16- and seven 1 15/16-inch plain babbitt bearings, was replaced by double ball-bearing hanger boxes. From this shafting fifteen single-deck spinning machines were driven. The wattmeter showed that with the original installation 1.85 kilowatts of power was used to drive the shafting only, and 1.65 kilowatts when the plain bearings were replaced by ball-bearing boxes—a saving of 0.20 kilowatt. The power for driving the shafts and the belts was 4.85 kilowatts with the original installation, and 3.90 kilowatts with ball bearings—a saving of 0.95 kilowatt.

Under normal operating conditions, that is, under the full load of fifteen machines, 17.8 kilowatts of power was used before the ball-bearing boxes were installed, and 15.8 kilowatts afterward, which represented a saving of 2 kilowatts, or the equivalent of 2.68 horsepower for the ball-bearing installation. The cost of power in this locality was especially low, being 1½ cents per kilowatt-hour. Figured on the basis of a fifty-hour week, this represents a yearly saving of:

2 kilowatts × 50 hours × 50 weeks × 1.5 cents = $75

The next test was conducted at the mill of D. C. Dery, Inc., Allentown, Pa., where plain types of lineshaft bearings were replaced by double ball-bearing hanger boxes. The lineshafting was 40 feet in length and was supported by five 2 7/16-inch plain bearing hanger boxes. Sixteen double-deck spinning machines were driven from this shafting. The wattmeter showed these results: For driving the lineshafting only, the power consumption with the original installation was 6 kilowatts, and with the ball-bearing installation, 4.25 kilowatts—a saving of 1.75 kilowatts. The power consumption for driving the shafts and belts with the plain bearings supporting the shaft was 10.25 kilowatts, while but 7.75 kilowatts of power was consumed with the ball-bearing installation—a saving of 2.50 kilowatts.

Under peak load, which is the normal operating condition, the wattmeter showed a consumption of 43 kilowatts when driving the sixteen spinning machines, and when the original plain hanger boxes were replaced by ball-bearing boxes, the saving in power appeared to be comparatively small, being only 0.75 kilowatt. The reading of the wattmeter, however, did not show all the conditions, which were as follows: A motor rated at 50 horsepower was used. The continuous load power consumption—43 kilowatts, which is equal to 57.5 horsepower—shows that the motor was overloaded. The line voltage was read at 202 volts or 8 per cent low for a 220-volt motor. The combined results of this overload and low voltage were reduced speed and an overheated motor.

In relieving these conditions by replacing the plain bearing boxes with ball-bearing hangers, there was an increase in spindle speed, but no direct indication of power saving. The use of ball bearings increased the spindle speed from 8500 to 9100 revolutions per minute, or 7.06 per cent, which means a corresponding increase in production. The power saving on the friction of the lineshafting alone, due to substituting ball-bearing hanger boxes, was stated to be 1.75 kilowatts; and in the case of the lineshafting and belting together, 2.5 kilowatts. This plainly indicates that with the increased friction load there was an increased power saving.

To express the decrease in friction load brought about by the use of ball bearings in terms of power saving, the percentage of speed increase may be conservatively used.

YEARLY SAVINGS WITH BALL-BEARING HANGER BOXES

Test No.	Saving in Oil	Saving in Labor	Saving in Power	Total
1	$4.75	$8.45	$75.00	$88.20
2	2.37	4.23	189.75	196.35
3	0.81	1.72	211.60	214.13

Machinery

That is to say, 7.06 per cent of the full-load power consumption (43 kilowatts), indicates a power saving for the ball-bearing hanger-box installation equivalent to 3.04 kilowatts or 4.08 horsepower. This, then, is the value that should be taken in calculating the actual saving in cost of power, and not the reading of the wattmeter (0.75 kilowatt), which does not reveal the true conditions at full load.

The cost of electric energy used in this test was 2½ cents per kilowatt-hour, which is probably an average rate. The yearly saving of which this test is indicative is:

3.04 kilowatts × 50 hours × 50 weeks × 2.5 cents = $189.75

In the third test, conducted at the Champlain Silk Mills, Brooklyn, N. Y., roller-bearing boxes, 1 11/16-inch size, were replaced with double ball-bearing hanger boxes. Six of these bearing boxes were used to support fifty feet of lineshafting, from which ten twisting machines were driven. The results of the comparative tests under the two installations were as follows: For the original bearing boxes 2.15 kilowatts of energy was consumed for driving the shaft only, and 2.075 kilowatts when the ball-bearing boxes were used—a saving of 0.075 kilowatt. To drive the shafting and belts, the wattmeter showed a consumption of 4.50 kilowatts with the original arrangement, and 3.875 kilowatts when ball-bearing boxes were used. This shows a saving of 0.625 kilowatt. Under normal conditions, when the ten twisting frames were in operation, the power used with the lineshafting running in the original bearing boxes was 17 kilowatts, and in the ball-bearing boxes 14.70 kilowatts. This represents a saving of 2.30 kilowatts or 3.08 horsepower.

The cost of electric energy was 3.68 cents per kilowatt-hour. Then the yearly saving in power is:

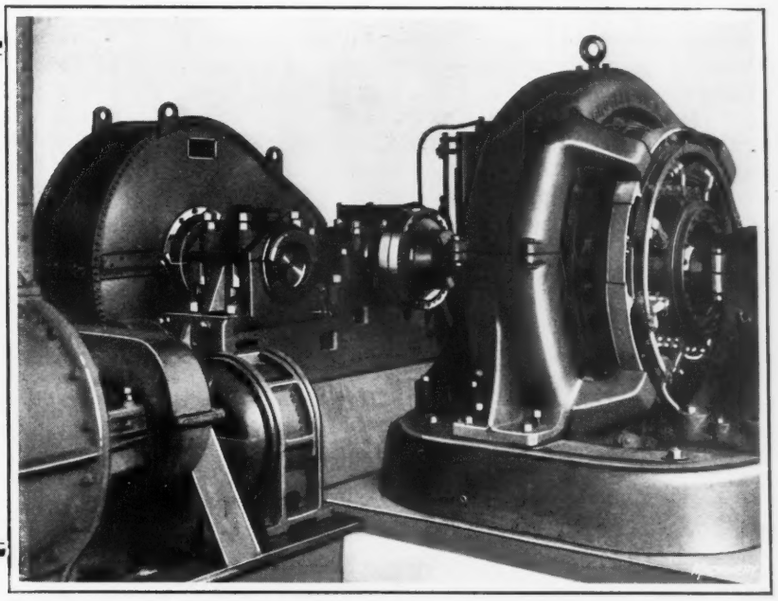
2.30 kilowatts × 50 hours × 50 weeks × 3.68 cents = $211.60

In addition to the direct saving in power, there were corresponding savings in oil and labor with the ball-bearing installations. The total direct savings per year for the three tests are summarized in the accompanying table.

Flexible Couplings

Where and How They Should be Used

By JOHN J. SERRELL
Smith & Serrell, Newark, N. J.



HOW much out of line will a flexible coupling run? This is perhaps the question most often asked about such couplings. Knowing that a costly misunderstanding may be encouraged in the minds of the few who glance at this first paragraph only, the writer will try to show those who study the full facts that the question referred to is often asked because of a misunderstanding. There are many more important things than the greatest allowable misalignment.

Basis for Selection of Prime Movers and Flexible Couplings

Since about 1890 there has been a marked development in high-speed machinery. This has been a competitive development brought about by the demand for a combined lower first cost and lower operating cost. A small high-speed motor developing 75 horsepower at 1800 revolutions per minute will cost much less than a motor or engine of the same power operating at 75 or 80 revolutions per minute. A small high-speed steam turbine, especially if its exhaust steam is used, may show even greater economy.

The selection of the kind and make of prime mover for driving any particular machine or group of machines is an engineering problem. The choice should be based on the first cost of the entire drive, the cost of power delivered to the driven machine, the cost of maintenance and repairs, and the assurance that the least possible delay in production will be caused by shutdowns, whether due to operating accidents or abuse. The same factors should determine the kind of flexible couplings to be used.

Direct-connected machinery having a driving unit supported in two bearings coupled directly to a driven unit, also supported in two bearings—or four bearings in a row—has been used for many years. Two bearings can be made self-aligning but no more. Therefore, it is necessary to line up the shafts of the connected machines.

Whether machines are to be direct-connected, or driven by belts, chains, or gears is another engineering problem. When a direct-connected drive is used, this selection is usually made because of economy in space, lower first cost, and lower maintenance cost—the combination representing a considerable saving.

Troubles Encountered where Direct-connected Machines have a Non-flexible Coupling

As the various kinds of prime movers have been developed and have been speeded up, builders and operators have experienced a lot of trouble with hot bearings, scored or broken shafts, broken couplings, loose keys etc. In fact, many entire installations have been wrecked either because (1) such direct-connected machines were not flexibly connected; (2) they were not properly aligned when installed; or (3) the alignment was not checked often enough to note and correct the errors in alignment always resulting from operation. It is difficult to line up four bearings with the necessary accuracy, and it is almost impossible to run them safely or economically without flexibility somewhere. With misalignment and a rigid connection, the chances are that either the coupling or the shafts will break, especially if the misalignment is excessive or long continued.

General Conditions Governing Use of Flexible Couplings

Lineshaft practice should not be confused with that followed for direct-connected machinery. With lineshafting, where it is usual to support the connected sections in hangers and bearings from 6 to 10 feet apart, there is usually sufficient flexibility to take care of any reasonable amount of error in alignment. Realigning at definite intervals will compensate for any slight inequality in the wear of bearings, slight settlements in the building, etc., and it is only in the exceptional installation that flexible couplings may show a saving over the usual rigid connection for lineshaft work. On direct-connected machinery, however, the shafts are proportionately much larger in diameter than those needed for the simple transmission of power, and the bearings are spaced relatively close together. These conditions are necessary in order to support the revolving weights rigidly, to minimize vibration, and to reduce over-all length.

Only in exceptional cases where the entire drive is most carefully designed and installed, where the operators are much above the average, and where constant attention is given to keeping the connected machines in exact alignment, can a rigid connection be used on direct-connected machinery. But if one machine is heavier than the other, if one bearing or one set of bearings is likely to wear faster than the others, or if operation of similar machines has shown that misalignment is likely and will cause trouble, then a flexible coupling should be used. On most high-speed direct-connected machinery it will be found that flexible couplings are used—or abused by those who ask the question mentioned in the opening paragraph of this article.

Initial Alignment and why it is Required

Most turbine builders line up their machines initially within 0.002 to 0.004 inch of the correct position. For lower

speeds and heavy duty, 0.010 inch is good practice, and such alignment should be obtained easily without micrometer gages. The exercise of due care to obtain good initial alignment will provide greater capacity to handle subsequent operating misalignment, but any specification of definite limits is difficult. The greater the speed, the greater the care desirable. The important point is to obtain the best initial alignment possible with the tools available, and then check it occasionally after operation.

The fact that the driving and driven units are received all set up on a common bedplate is no assurance that they will be in proper alignment if installed without reasonable precautions. A bedplate can be sprung to a considerable extent by its own or the machine's weight due to being improperly supported or as the result of piping or internal strains. The alignment should always be checked before operating a new unit or upon assuming responsibility for the satisfactory performance of such drives.

Flexible Couplings for Various Kinds of Drives

There are many types and makes of flexible couplings. A shaft connection which simply delivers power when the shafts are at an angle is usually called a universal joint, and it should not be confused with a flexible coupling which is intended primarily for a straight-line drive, but will accommodate small angular and off-center misalignments and will also allow for some variation in endwise setting or endwise movement.

On small drives operating at moderate speeds where low first cost has been the only consideration, there are several types of flexible couplings using leather, rubber, or fabric as the flexible element. Where there is no backlash, the load being applied continuously in one direction without sudden or repeated reversal, it has been found satisfactory in some cases simply to have sufficient clearance between the contacting parts, provided that the alignment is maintained within very close limits, as such devices usually result in line or point contact and rapid wear occurs if there is misalignment.

Special types of couplings have been developed for continuous process work, as on steel rolling mills, where the capacity of the coupling for misalignment is really important. In designing couplings for such service, it is usual to sacrifice a considerable amount of over-all length in order to use what really amounts to two flexible couplings connected by an intermediate shaft, which may vary in length according to the probable maximum amount of off-center misalignment.

An all-metal type of flexible coupling is adapted for heavy-duty work, because of the smaller size involved, longer life, and less cost—first and last. Many drives are started suddenly, and one machine may impose a fluctuating or vibratory load on the other. For such drives it is often desirable to have a cushioning effect between the machines, which is supplied by coil springs or by laminated bundles of springs in the all-metal types.

Checking Coupling Alignment at Regular Intervals

With any flexible coupling, reasonable care should be used to obtain good initial alignment, and this should be checked at regular intervals. When a coupling is carefully lined up at the time of installation, its capacity for handling subsequent operating misalignments is increased, and it is better to check the alignment than to buy new machine and coupling parts. Regular checking will prevent excessive misalignment of long duration, which, with many couplings, will impose destructive strains on the connected machines if beyond the intended capacity of the coupling. With the laminated steel pin type, however, the replaceable units act as a safety device in the case of an operating accident and will yield if the misalignment is excessive, before serious damage is done to the connected machines.

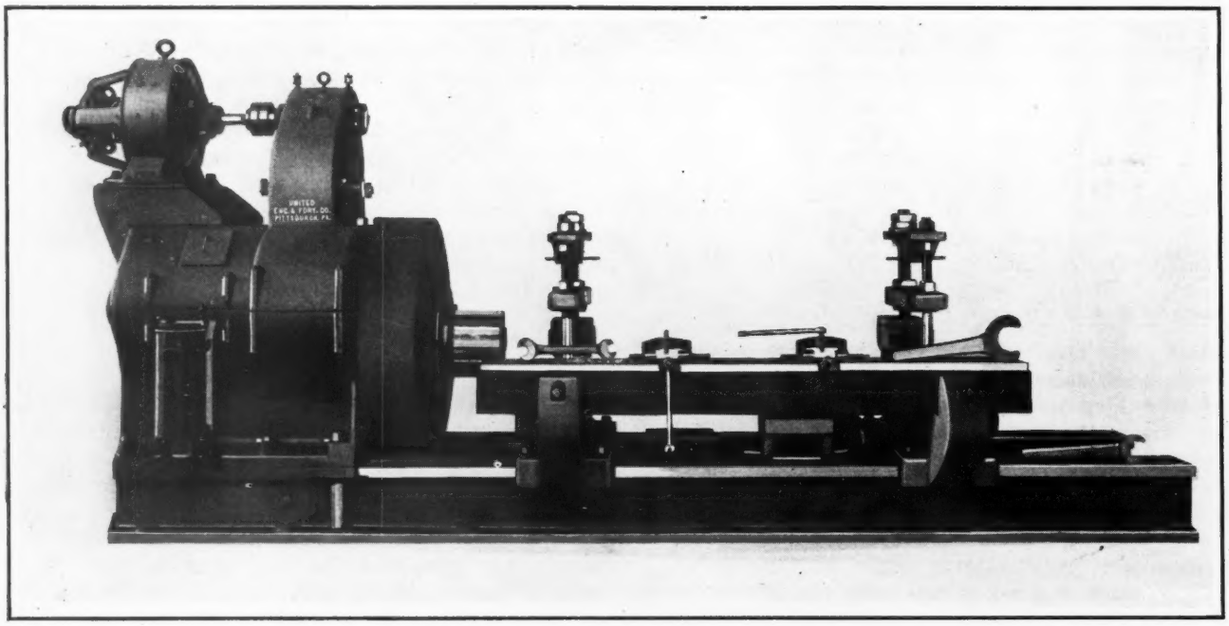


Fig. 1. Motor-driven Roll-turning Lathe with Flexible Coupling Connection—Such Couplings are often used on Large Machine Tools

For simplicity in lining up or checking the alignment, both flanges should be of the same diameter and true with the bores. The flanges should be faced off square so that the angular alignment can be checked simply by measuring the distance between flanges. Out-of-center misalignment may be tested accurately enough for practical purposes by placing a straightedge across the coupling flanges, assuming that they are of the same diameters.

Points on Flexible Coupling Design

There should be no projecting unprotected parts on any flexible coupling to catch the clothing or hands of operators. On high-speed couplings there should be no parts to work loose or fly out.

For most direct-connected work it is desirable that the coupling shall be extensible, that it shall be flexible for off-center and for angular misalignment, and that it shall not impose excessive strains on the connected shafts even in case of excessive misalignment. Others things being equal, the capacity of the coupling to handle misalignment

is important. The coupling should be readily assembled and taken apart. It should not be necessary to move one or both connected machines or their shafts to renew the wearing parts of the coupling. The various parts should be interchangeable so that they will not require expensive hand fitting, with the resulting high cost for renewals.

Misalignment will occur even on a carefully installed and well operated drive—sometimes excessive misalignment—and this means wear. The rapidity of the wear will depend upon many factors, principally upon the speed of the drive and the degree of misalignment.

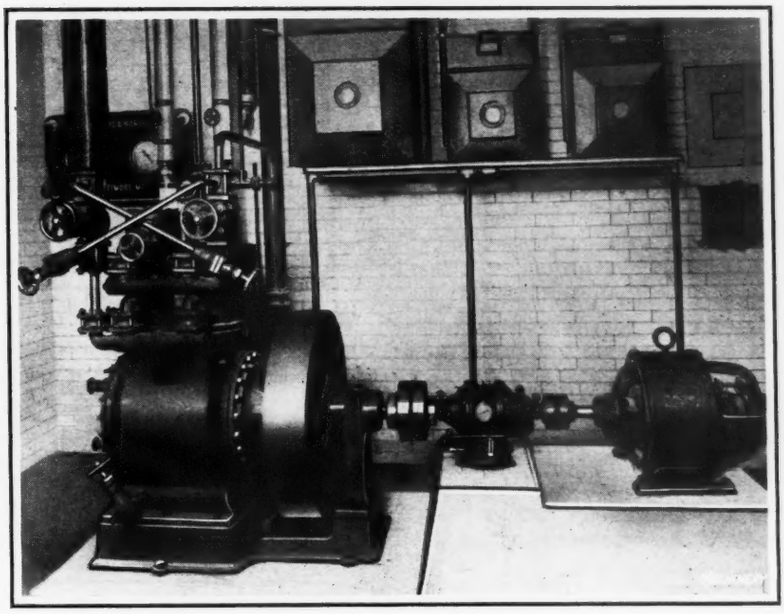


Fig. 2. Installation using Two Flexible Couplings—One between a 15-horsepower Motor and a Reduction Gear, and the Other between the Gear and an Ammonia Compressor

Size and Capacity of Flexible Couplings

Correct size selection is essential to satisfactory coupling and machine performance. Often there are unusual demands made on a flexible coupling. The loading is not always apparent without previous experience, and sometimes a word of advice or a suggestion from the service department of the coupling manufacturer will turn an apparently unsatisfactory drive into one that gives real satisfaction. These are the most important considerations in selecting or recommending a flexible coupling, especially with reference to how it is installed and used; in fact, they are far more important than the mere question of how much a coupling can be run out of line.

Most successful flexible couplings are designed with definite factors in mind. If fabric, rubber, etc., is used, the tensile strength or the compressive strength is generally the factor that determines the capacity of the coupling. These parts should be renewed fairly often so as to maintain the intended flexibility. If looseness of parts is the source of flexibility, then these parts should be renewed before excessive wear takes place.

When full flexibility in all-metal couplings is obtained by combining sliding movements with flexibility of materials, the unit bearing pressures and the fatigue strength of material must be considered. Lubrication of such sliding surfaces is advisable under exceptional conditions, but if the bearing pressures are relatively small and misalignment is not excessive, many years of protection from each set of coupling parts should be obtained without constant attention and lubrication.

If any flexible coupling fails to give complete protection against misalignment, if the parts wear out repeatedly or quickly, or if the coupling advertises wear by making a noise, it undoubtedly does so as the natural result of some cause. Approach such "trouble" with an open mind. Check up the alignment with the machines standing idle and check it again as carefully as possible with the machines operating under load. If the foundations are not sufficiently rigid or if the machine frames, bearings, etc., are not adequate, vibratory misalignments may be developed under peak loads and these may be the cause of operating troubles. Measure the spacing between flanges to note whether the coupling is operated within its intended mechanical limits. Observe whether the parts are so badly worn as to require renewal. Obtain the maximum load conditions imposed on the coupling, as the loads may be greater in actual practice than figured theoretically. Such a methodical examination will often locate the trouble and enable the cause to be eliminated so that the whole drive will again give entire satisfaction.

* * *

Great strides have been made by the Belgian engineering standardization committee. The standards of particular interest in the machinery field that have been adopted relate to shafts and pulleys, bolts and rivets, chain and wire rope. Copies of the standards can be obtained from the American Engineering Standards Committee, 29 W. 39th St., New York.

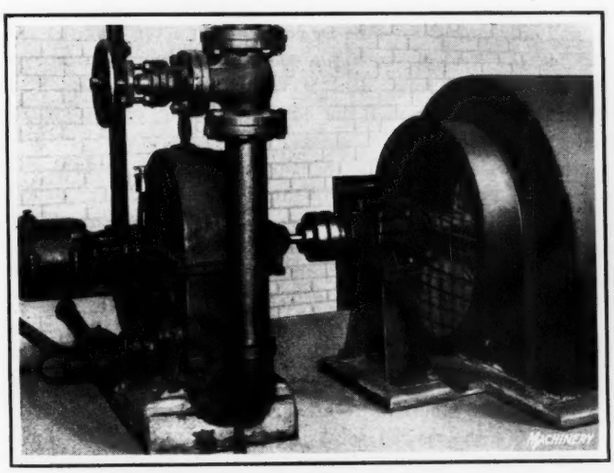


Fig. 3. Turbine-fan Installation using Flexible Coupling—Direct-connected Steam Turbine Drives have Flexible Couplings to compensate for Misalignments due to Expansion and Wear

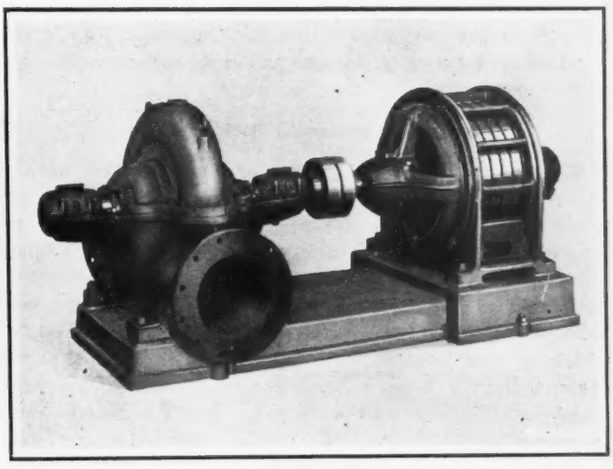


Fig. 4. Motor and Centrifugal Pump connected by Flexible Coupling—Even when mounted on a Common Bedplate, Alignment should always be checked after Installation

Inspecting Bearing Rollers by Machine

SATISFACTORY service can be obtained from roller bearings only if all the rollers are of the same diameter within close limits. It is not so important that they be of precisely the specified size; the main point is that they be uniform, so that each roller will carry its due proportion of the load. In cases where there is a lack of uniformity, the large sized rollers will be called upon to carry more than their share of the load. This condition soon results in wear, and it is a recognized fact that when wear once starts in either a roller bearing or a ball bearing, it proceeds rapidly until the bearing is destroyed.

The sorting of rollers by hand into groups varying by but a few ten-thousandths inch, is a slow process and usually

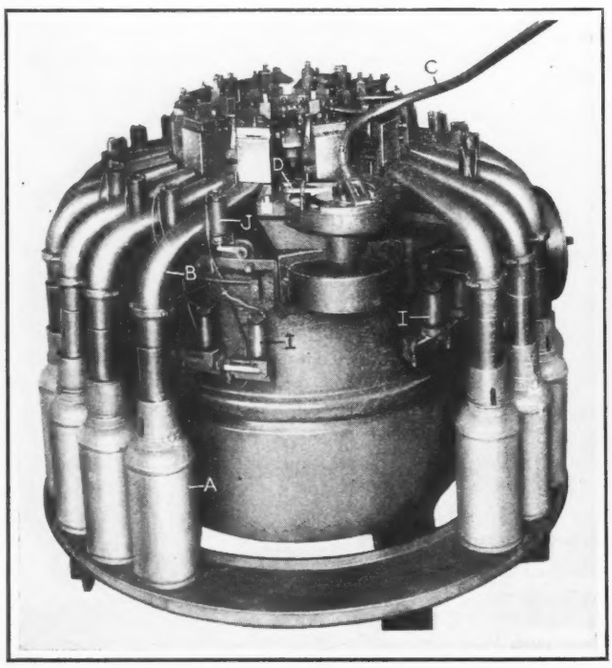


Fig. 1. Machine used in the Plant of the Bock Bearing Co. to inspect Rollers for Roller Bearings

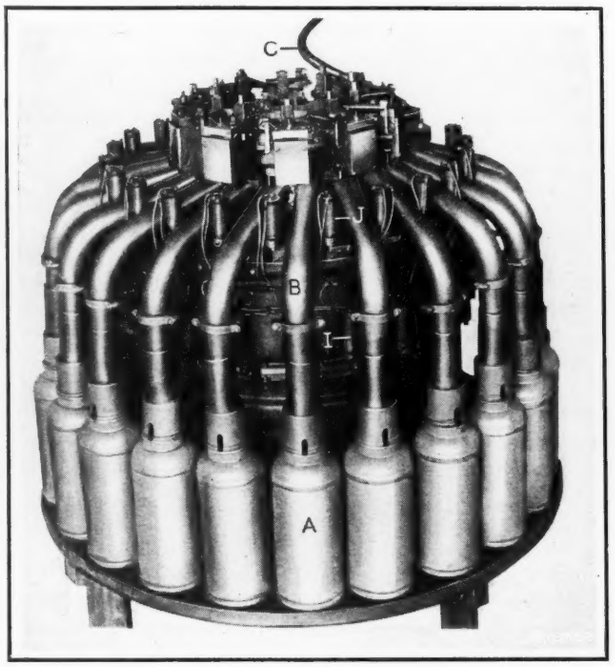


Fig. 2. Opposite Side of the Inspecting Machine from that illustrated in Fig. 1

requires a considerable number of employes. At the plant of the Bock Bearing Co., Toledo, Ohio, the most highly skilled inspectors could not gage more than 3000 rollers per ten-hour day. To lower the inspection cost, this company developed the ingenious machine shown in Figs. 1 and 2, which automatically inspects and sorts rollers at the rate of 3000 per hour.

Inspecting Rollers for Bock Bearings

The rollers in Bock bearings are tapered and have a spherical head. When they pass from the gaging machine to the assembling department there is positive assurance that all the rollers in a bearing will be of the same diameter within 0.0002 inch. Reference to the illustrations will show that the machine is circular in form and surrounded by a ring of nineteen containers *A*, into each of which a steel chute *B* leads. The rollers to be gaged descend from a hopper through chute *C* to gaging heads which carry them successively around a circular path. In making this circuit, each roller passes by entrances to the chutes leading to the containers, and when a given roller reaches the chute leading to the container that receives rollers of its particular size, the gripping mechanism is automatically released, thereby permitting the roller to drop into that container.

Operation of the Machine

When each roller reaches the lower end of chute *C*, a cam-actuated lever mechanism *D*, Fig. 1, pushes it forward between a pair of gripping jaws indicated at *E*, Fig. 3, which are tapered to conform to the shape of the roller. The upper jaw *E* is movable so as to accommodate rollers of different sizes, but the lower jaw is fixed. After a roller has been gripped between these two jaws its head slides along the smooth face of the cam-actuated lever *D*, Fig. 1, and enters the V-shaped slot of a third gaging block *F*, Fig. 3. The roller is pushed into contact with the V-block by compression spring *G*. After the head of a roller has been pushed against the V-block, the upper jaw *E* is locked in place. Thus the roller, as held by the three gaging members, is not only gaged for size as regards diameter, but the contact of the V-block with the spherical bearing surface on the head of the roller also serves to gage the relation between this surface and the conical bearing surface of the roller.

It has already been mentioned that a cam-actuated mechanism pushes the rollers into position between jaws *E*. As each roller descends from chute *C* it is automatically turned to enter the jaws in the proper manner. The raising of the upper jaw is also controlled by a cam mechanism, and the operation of the two sets of cams is synchronized so that the jaw automatically opens as the roller to be gaged is pushed forward. There are ten gaging heads, one between each two containers and the frame on which the gaging heads are mounted rotates continuously. Behind each upper jaw and secured to it is a short arm *H*, Fig. 3, the under side of which is accurately finished. This finished face moves over a series of electrical contacts made of copper, as the gaging head rotates. The contacts are

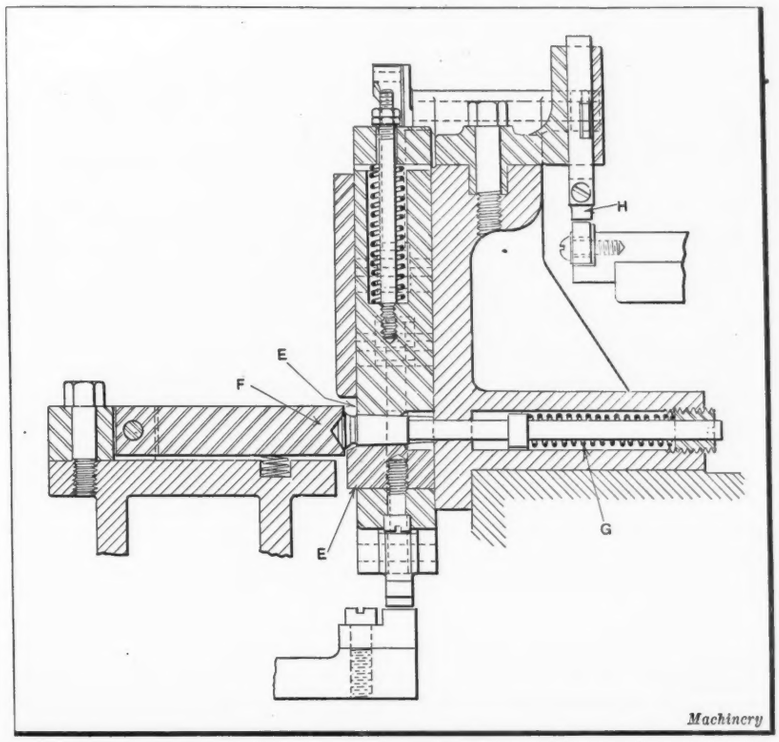


Fig. 3. Diagram of the Roller Gripping and Ejecting Mechanism

stepped progressively in increments of 0.0002 inch, and each contact is located opposite one of the containers.

When a roller is brought opposite the container that receives rollers of its particular size, the arm *H*, upon reaching the electrical contact, causes the current to be shunted through an electric coil *I*, Fig. 1, shutting off the current from coil *J* through which it normally passes. This, in turn, causes an electromagnet to release a cam which swings upward, and in so doing engages the cam that controls the upper jaw *E* which holds the roller in position. This action raises the upper jaw, and thereby releases the roller so that the spring *G*, Fig. 3, may eject it into the chute leading to the container.

Accuracy of the Sorting

The operation of the machine is entirely automatic, it being merely necessary for the attendant to keep the supply hopper filled with rollers so that they may be continuously fed to the gaging heads. The first container receives all rollers larger in size than the maximum limit allowed on the nominal size. The next seventeen containers receive rollers differing in size by increments of 0.0002 inch, and the nineteenth container receives all under-sized rollers.

The contents of the first and the nineteenth containers are not necessarily scrap, because the machine does not sort to quite the maximum and minimum limits. For instance, on rollers having a nominal diameter of 0.3750 inch, the limits are + 0.0030 and — 0.0010 inch. As the seventeen containers receive rollers varying in size by 0.0002 inch, they provide for a total tolerance of 0.0034 inch. Consequently, there is still a range of 0.0006 inch in which the size of these rollers may deviate from the nominal diameter before they exceed the limits. The large rollers are sent back to the grinding department for regrinding and then returned to the gaging machine, where it is usually found that most of them come between the prescribed limits. Only the under-sized rollers are finally rejected as scrap.

CENTERING AND FACING AUTOMOBILE PISTONS

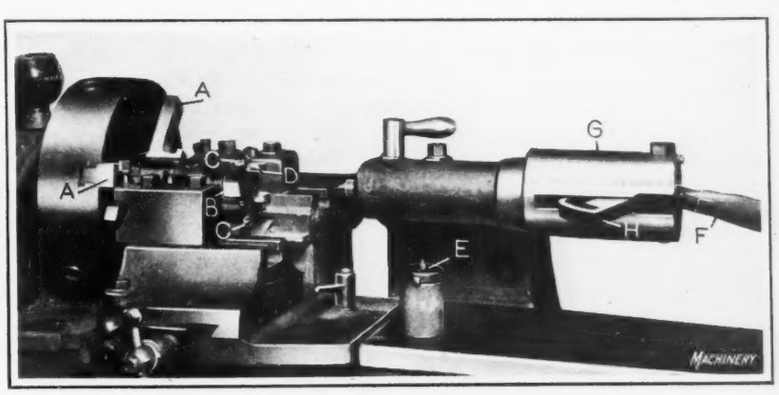
The accompanying illustration shows a Porter-Cable lathe especially arranged for centering and facing over-size pistons. This equipment is regularly used in the plant of the Houpert Machine Co., Long Island City, for the first operation in the manufacture of over-size pistons which this company carries in stock in rather large quantities. The pistons are chucked from the inside of the web of the skirt end by means of the special hook jaws *A*. A spring-backed centering arbor *B* is operated by a draw-in collet, and consists of a specially designed end which has four fingers *C* to engage the inner wall of the piston near the piston-pin bosses, and a V-block *D*, which seats on these bosses.

With the work thus located, a knurled holder *E* in which the centering tool is carried is employed to center the end of the rough casting. This tool-holder is slipped over the regular 60-degree lathe center and is advanced to center the end by means of handle *F*. An extension *G* is attached to the regular tailstock, through which the lathe center extends, this end of the center being slotted to carry a cam-roller. The cam-roller operates in cam *H*, the shape of which is designed to feed the centering tool to the proper depth. When this point is reached, the handle is pushed back slightly, the centering tool-holder removed and the lathe center advanced into the 60-degree center in the work, where it is locked as the cam is pivoted around further by the handle *F*. Facing tools in the front and rear tool-blocks then rough- and finish-face the skirt end of the pistons.

* * *

AN INSTRUMENT FOR OBSERVING MOVING PARTS AT HIGH SPEED

The oscilloscope is the name given to an instrument which should be of considerable aid to designers of machinery, since it permits of an exact study and measurement of the movements of machinery parts functioning at high speeds. The principle upon which the oscilloscope works is interesting. The apparatus illuminates the moving object to be examined with a series of flashes from an electric lamp, these flashes being arranged to take place at regularly spaced intervals during the movement of the part. In other words, it enables the eye to take a series of flashlight photographs in regular sequence, and in such a way that the part appears to be moving at one-hundredth of its actual speed. The use of this instrument opens up an entirely new field in the investigation of machine tool operation at high speed.



Lathe with Special Tailstock and Auxiliary Centering Tool

Selling Machine Tools by Motion Pictures

By EDWARD K. HAMMOND

THE old proverb "To see is to believe" sets forth a fundamental principle of psychology. The average man is likely to be more impressed by what he actually sees than by what he hears, and it is for this reason that motion pictures have been made use of in selling manufactured products, especially engineering equipment. But aside from the fact that it is easier to believe a visible message than a spoken one, the motion picture has other advantages as a means of selling machine tools and shop accessories. Purchasers of factory equipment are fundamentally interested in what the machines are capable of doing. With this in view, it is the practice of some machinery builders to take their prospective customers to plants in which tools are being used on the same general line of work as that on which they are engaged. This often involves loss of time, and represents a considerable expenditure for traveling and hotel bills. Hence when it is necessary to do a great deal of "missionary" work of this kind to effect a sale, a large part of the profits resulting from the transaction is often swallowed up.

It is not unusual for a thoroughly capable machinery salesman to call upon a "prospect" a great many times before he is successful in getting him to visit a plant where the machines can be seen in operation. Aside from the problem of breaking down the customer's reserve and possible opposition to certain features of the proposition, it may be very hard to find a time when he can conveniently arrange to go and see the machines at work. The moving picture overcomes this difficulty by taking a view of the operation right to the prospective customer's office, where he can see and comprehend all the important details; and the interest which is aroused by the film exhibition is often an important factor in overcoming any opposition which may be encountered. It is important to note that the film not only shows the machine at work, but also the operating conditions, so that the customer will be assured that they are similar to those in his own plant.

Advantages of Portable Moving Picture Projection Machines

Portable projection machines are made for the use of salesmen. They are packed in cases which are of a convenient size to carry and weigh only from twenty to twenty-two pounds. Added to this, there is usually a 1000-foot roll of films, which weighs from ten to twelve pounds. The machine is motor-driven, power for this purpose being taken from an ordinary light socket; and a picture can be thrown on an ordinary wall or other opaque surface. It requires about fourteen minutes to show a full reel of film. Pictures of this kind are made on the so-called "non-flam" films which are said to eliminate danger of fire. When it is not convenient to show a film in a business office, arrangements can often be made for using the apparatus in a "movie" theater during the mornings when regular exhibitions are not in progress.

Requirements of a Successful Film

The reason for using films in demonstrating the merits of industrial plant equipment is that the customer, sitting in his own office, can obtain an accurate conception of working conditions in a plant where one of the machines in which he is interested is in operation. This being the case, it is evident that the greatest care should be exercised to have the film accurate in all details. The machine should be set up and running on an actual job, and before starting to make the film it should be ascertained that all details of the tooling and other essential features are accurate.

Some films have been made with a so-called story or plot worked into them; but as the purchaser of machine tools is interested chiefly in what they are capable of accomplishing in the way of production, it is probable that nothing will prove more interesting or effective in producing sales than a film that portrays actual working conditions. Before starting to make a picture, a definite plan of action should be evolved and approved by the sales manager and other officials of the machinery building corporation. The film should be planned in such a way that it carries a powerful selling argument. A film should never be made longer than is absolutely necessary to tell the story. Reiteration often dampens the interest of the customer.

Arranging to Exhibit the Film

After a film has been made, it must be brought to the attention of men who have authority to make purchases. It is obvious that the most carefully prepared film cannot be of any value unless it is kept in circulation among those who are prospective purchasers of the equipment that is being shown. When salesmen carry films with them to supplement their discussion with customers, they are used regu-

For information contained in this article, the author is indebted to R. L. Herrick, motion picture industrial engineer, and to the Baumer Films, Inc., 6 W. 48th St., New York City. The projector shown in the title illustration was made by the De Vry Corporation, 141 W. 42nd St., New York City.

larly as a selling argument. But if films are used as mediums of general publicity, the advertising manager should see to it that they are kept in circulation, and that the places of exhibition are such that the films are likely to be seen by a sufficient number of prospective customers to justify the expense of their preparation.

Adapting the Film for its Purpose

In conducting general publicity work, films can often be advantageously employed for advertising products that are commonly shown in the popular magazines and other national advertising mediums. Arrangements can sometimes be made to show cleverly developed advertising films on the screens of the moving picture theaters where a charge is made for admission. In such cases, however, the story shown by the film ought to be developed along lines which emphasize elements of human interest and make publicity an incidental factor.

It would be difficult, of course, to find a sufficient number of prospective buyers of machine tools and shop equipment in regular movie theaters to warrant the making of films and the spending of time in arranging for their display. The better plan is to make films that are of sufficient technical interest so that various engineering societies throughout the country will be glad to arrange for their display at their regular meetings. Here the manufacturer shows his film before an audience largely composed of men who directly or indirectly influence buying. The same benefits should result from showing films in technical schools and before gatherings of students attending Y. M. C. A. evening courses.

How One Firm Used a Film

A number of industrial motion picture films have been made and used with gratifying results. As a case in point, a film demonstrating the application of a new type of air-operated tool was made. This film was originally made in three reels, so that approximately forty-five minutes was required for its exhibition. It showed the tool in use and had a lively story interwoven, so that there was plenty of the human interest element.

After the film was completed, a smoker was given at each of the branch offices of the company, to which possible buyers of these tools were invited. A pleasant evening's entertainment was provided, of which the showing of the film was only a part and, incidentally, the use of the new tool was brought to the attention of a group of men who had the authority to purchase it. After this preliminary showing, all the story was eliminated from the film, so that it became a purely technical demonstration of a pneumatic tool. With the idea of using it in this way, the film was made with the story in the first and third reels. The second reel was simply a technical demonstration of the tool. There have been over 500 showings of the film before a total of 50,000 men.

Types of Films Used for Industrial Motion Pictures

An ordinary moving picture film is run through the projecting machine at a speed of sixteen "frames" per second, and there are sixteen frames to a foot of film. As the film runs through the projection machine, these pictures are substituted for each other on the screen with such rapidity, that the eye is incapable of following the changes, with the result that one gets the impression of a machine or other object in motion. "High-speed" films are made by running the camera eight times as fast as the "normal-speed" projecting machine is operated. Then, in exhibiting the film produced in this manner, the projecting machine is run at normal speed. As a result, it is possible to photograph the movements of a mechanism that operates too fast to be followed by the eye, and then to slow the projection down, so that the movements can be readily followed when the moving picture is shown on the screen. This is a valuable device for many lines of work, but there are few machine tools that operate fast enough to require films of this type.

The so-called "technigraphs" or animated drawing films are useful for showing cycles of movements. This method is valuable for showing the movements of the valves and pistons of a gasoline engine or the parts of various other mechanisms; but films of this kind are rarely applied in demonstrating machine tools. A new development in the motion picture industry is the stereoscopic film, which provides for giving exceptional depth to the view projected on the screen. This is a development in the industry which promises to give valuable results, although at present it is in a more or less experimental stage.

Cost of Making a Film

After reading the foregoing analysis of ways in which a motion picture film can be used to advantage in selling machine tools, the question naturally arises, "What will it cost to make a film?" The projection machine will cost from $225 to $250, and ordinary films of good quality can be produced for from $1000 to $2000 for a 1000-foot negative. High-speed films, and films showing animated drawings or so-called "technigraphs" cost considerably more, ranging in price from $4000 to $10,000. However, such films are not often required to show machine shop operations. After the negative has been produced, prints can be made from it at a cost of from $100 to $150. When a firm has a number of salesmen on the road and it is desired to have each man carry a film, it will be evident that the possibility of making an unlimited number of prints greatly reduces the cost of this method of demonstrating machine tools.

* * *

COMING MEETING OF INTERNATIONAL CHAMBER OF COMMERCE

The second general meeting of the International Chamber of Commerce, an organization which includes delegates from all the leading nations of the world, will be held in Rome, Italy, March 18 to 24, 1924. Invitations to participate in this meeting have been extended to Chambers of Commerce and trade organizations in the United States, as well as to a large number of business men throughout the country. The present indications are that there will be from 200 to 300 American business men in attendance. Further information may be obtained from Lacy C. Zapf, secretary of the American Section of the International Chamber of Commerce, Mills Bldg., Washington, D. C. In order to enable members of the American Section who attend the meeting to broaden their knowledge of international affairs, a special tour will be arranged, which will offer an opportunity for those attending to study commercial and economic conditions in the Mediterranean countries, the Near East and Western Europe.

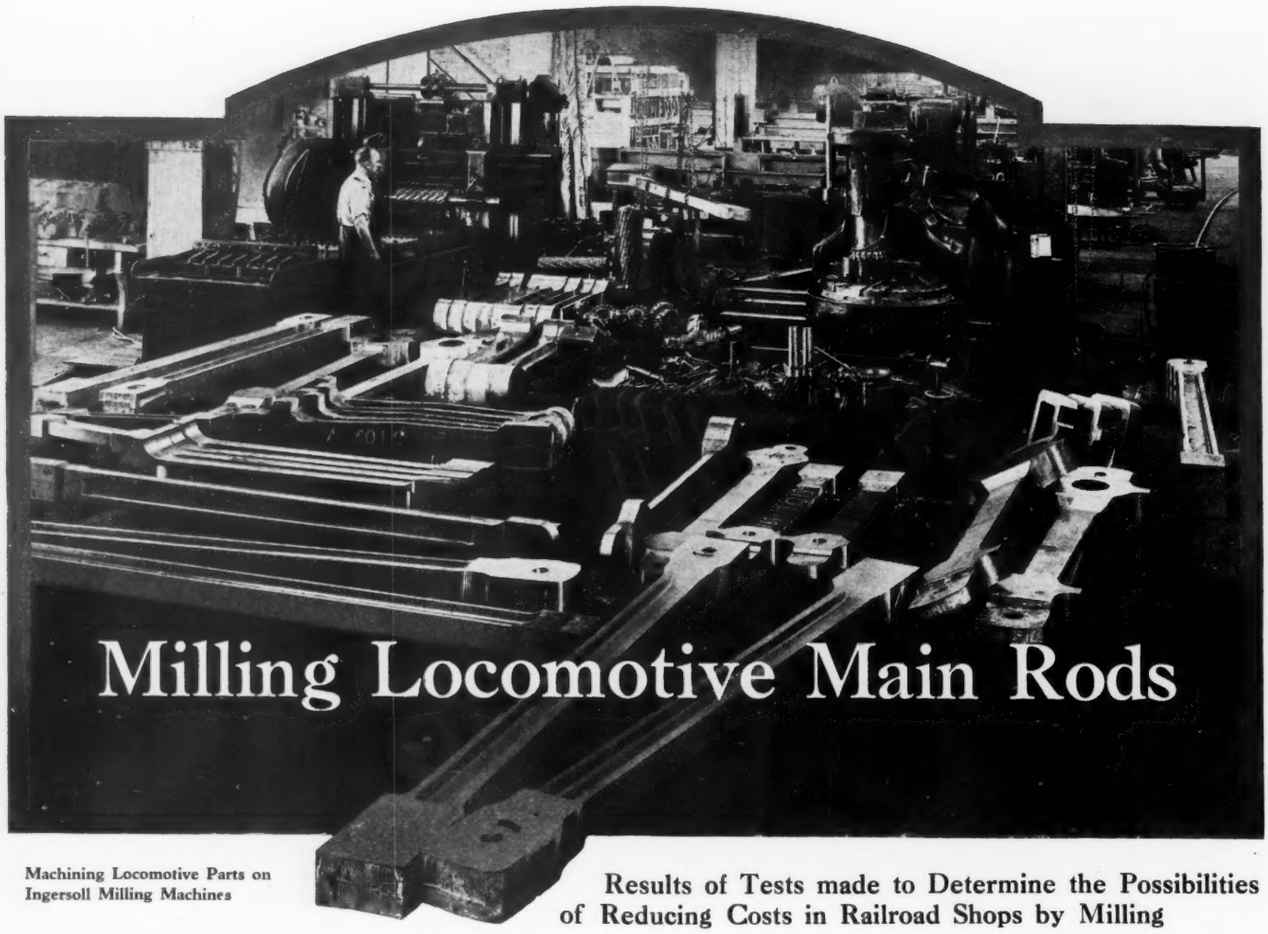
* * *

VALUE OF MACHINE TOOLS AND METAL-WORKING MACHINERY EXPORTED TO JAPAN, 1912-1921

Year*	Lathes	Sharpening and Grinding Machines	Other Machine Tools	Total of Machine Tools	All Other Metal-working Machinery	Total of Machine Tools and Metal-working Machinery
1912	.....	.....	.....	.....	.....	$133,546
1913	.....	.....	.....	.....	.....	119,558
1914	.....	.....	.....	.....	.....	120,166
1915	.....	.....	.....	.....	.....	86,166
1916	.....	.....	.....	.....	.....	437,159
1917	.....	.....	.....	.....	.....	1,092,317
1918	$577,440	$221,961	$476,215	$1,275,616	$1,249,660	2,525,276
1919	967,095	452,233	635,874	2,055,202	3,327,982	5,383,184
1920	503,304	494,154	956,784	1,954,242	2,296,341	4,250,583
1921	301,028	198,236	430,462	929,726	1,706,292	2,636,018

Machinery

*The figures given are for fiscal years up to and including 1918, and for calendar years thereafter. Detailed statistics not available for years previous to 1918.



Milling Locomotive Main Rods

Machining Locomotive Parts on Ingersoll Milling Machines

Results of Tests made to Determine the Possibilities of Reducing Costs in Railroad Shops by Milling

MACHINE tool manufacturers have given particular attention to the railroad field during the last two or three years, and as a result machines have been developed which, if generally used, would greatly reduce production costs in railroad shops. In tests recently conducted by the engineers of the Ingersoll Milling Machine Co., Rockford, Ill., various locomotive parts were machined by milling, the tests being carried out under conditions that could easily be duplicated in actual practice. Some of the results of these tests, which covered a period of three months, are set forth in this article.

Machines and Equipment Used in the Tests

For handling this class of work, two heavy-duty milling machines especially built for railroad shop work were employed. A planer-type horizontal milling machine was used for taking heavy cuts on the sides and edges of rods, and an adjustable rotary machine (also of special construction) was used for such operations as milling contours on the ends of connecting-rods, where a vertical type machine is inherently advantageous.

For the slabbing operations and for certain contour milling, a helical inserted-tooth cutter of special design was employed. The teeth in these cutters were made of high-speed steel, twisted into a helical shape. The advantages claimed for this special type cutter are that the shearing cut which it takes removes metal with an economical expenditure of power and that the surface produced has a smooth finish, provided, of course, that the proper speeds and feeds are used. The teeth of these cutters are held in place by hardened wedges and screws. This type of cutter is shown in use in Figs. 1 and 2 on the horizontal type of machine, and in Fig. 4 on the vertical machine.

For performing grooving operations, another cutter of special design was used in the test, the general appearance of which is shown in Fig. 3. These cutters have staggered inserted teeth, and are 10 inches in diameter, with a face width of 3¼ inches. The teeth are of high-speed steel and set at alternate angles, held in place by wedges and screws. The spacing of the teeth is great enough to allow liberal chip clearance.

Fixtures that are designed to hold connecting-rods so securely that a high table feed can be employed and that have provision for accurately and rapidly setting up a job were designed by the engineering department of the Ingersoll Milling Machine Co. These fixtures can be quickly adjusted and will accommodate locomotive rods of all makes. Some idea of the design may be had by referring to Fig. 1. They consist of hardened and ground plates that extend across the table and are provided with slots to accommodate clamp brackets which are located in different positions for clamping locomotive rods of various sizes. The brackets carry bolts which may be adjusted against the side of the work without obstructing the passage of the cutter. Patents have been applied for, covering the design of these fixtures as well as the special helical and staggered-tooth cutters.

Speeds, Feeds, and Material

The material of the locomotive forgings machined was, as a rule, a special chrome-vanadium alloy steel, heat-treated. The analysis and physical properties of this steel are as follows: Carbon, 0.38 to 0.48 per cent; manganese, 0.75 to 0.90 per cent; sulphur, 0.04 per cent (maximum); phosphorus, 0.04 per cent (maximum); chromium, 0.80 to 1 per cent; and vanadium, 0.15 per cent (minimum). The physical results of a typical test on an alloy steel rod of this analysis showed an elastic limit of 62,750 pounds per square inch; a tensile strength of 98,850 pounds per square inch; an elongation in two inches of 23 per cent; and a reduction in area of 53.3 per cent.

The scale on these forgings was exceptionally hard, and it was necessary in milling the sides and edges to use a comparatively slow cutter speed and to reduce the table feed correspondingly. In channeling, however, where there was

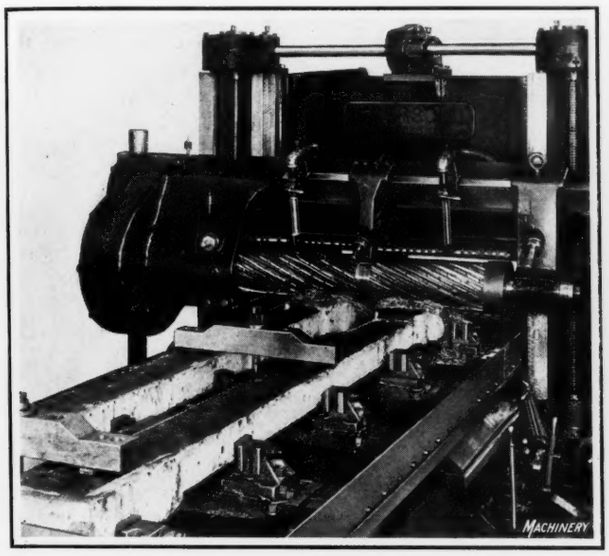


Fig. 1. Slabbing the Sides of Locomotive Main Rods

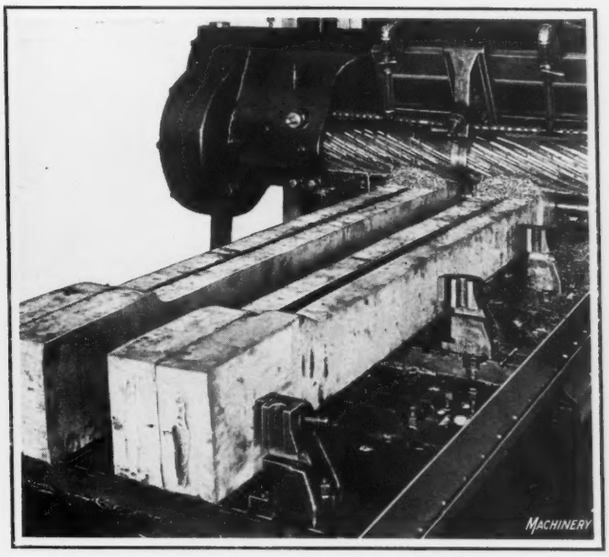


Fig. 2. Milling the Edges of Locomotive Main Rods

no difficulty from scale, it was possible to use a faster rate of speed and increase the table feed.

In machining locomotive main rod forgings, seven operations were performed, six of which were milling. The first consisted of slab-milling both sides of two forgings. The set-up for this job is illustrated in Fig. 1. Here the planer-type horizontal milling machine previously referred to is shown set up with two helical milling cutters and adjustable rod fixtures of the type previously described. The cutters are 9 inches in diameter and 24 inches long, and in the test were run at a speed of 33 feet per minute. As the scale on the forgings was exceptionally hard, it was necessary to reduce the cutter speed considerably, the table feed being likewise reduced to 3 inches per minute. This rate of feed, however, produced an exceptionally fine finish. The depth of cut was 19/32 inch, the total width of cut, 23 inches, and the amount of stock removed per minute, 41 cubic inches. The horsepower required per cubic inch of metal removed was 1.45, and the production time, floor to floor, for slabbing both sides of these two forgings was three hours and twenty-eight minutes.

The second operation consisted of drilling a hole in the piston end. This hole, which is 2½ inches in diameter, was drilled in the piston end and an arbor was passed through it for lining up the two forgings during the edge milling operation. The set-up for the edging operation is illustrated in Fig. 2, which shows the arbor passing through two pairs of forgings to locate them relative to the cutters. The cutters used for edging were the same size and type as those used in the first operation and the feeds and speeds were the same. The depth of cut was 11/16 inch, the total width of cut, 20¾ inches, and the amount of metal removed per minute, 41 cubic inches. The horsepower required per cubic inch of metal removed was 1.38, and the floor to floor time for both sides of four rods was three hours and forty-two minutes.

After edging, the rods were set up in pairs on the horizontal type machine, preparatory to milling the tapered channels. Fig. 3 shows the set-up and the staggered inserted-tooth channeling cutters used. These cutters are 3¼ inches face width and 10 inches in diameter, and the cutter speed for this operation was 58 surface feet per minute, with a table feed of 5½ inches per minute. In this connection it will be noted that the cutter speed was increased over that used in the slabbing and edging operations because in this case there was no hard scale to interfere. The higher cutter speed resulted in the table feed being increased proportionately. The depth of cut was 1 9/16 inches. Two cuts were taken in each channel, the first of which was 3¼ inches wide, and the second, with the rods set over to the proper angle, tapered from ¾ inch to 1¼ inches. The total amount of metal removed per minute by both cutters was 58.6 cubic inches, and the horsepower required per cubic inch, 1.13. The production time for completing four of these channels, one on each side of each rod, was five hours and ten minutes.

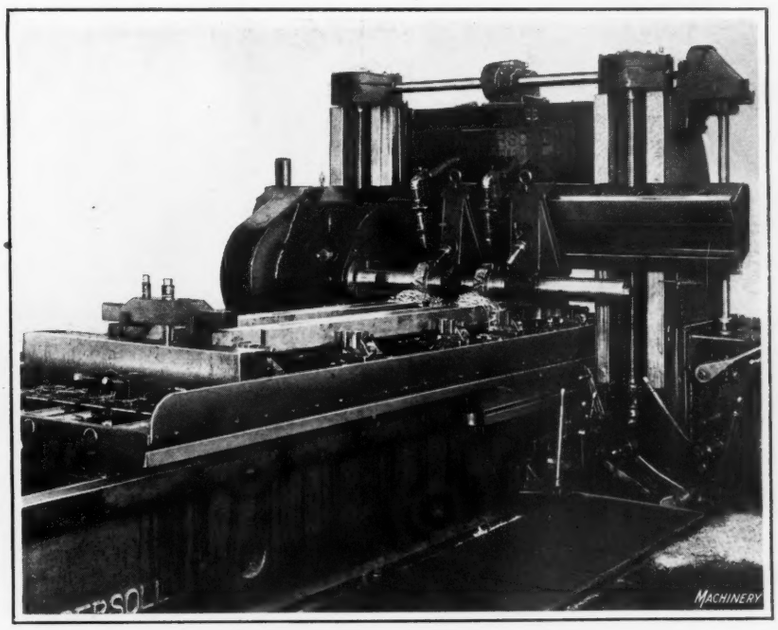


Fig. 3. Milling Tapered Channels in Locomotive Main Rods

The three other milling operations required to finish the main rods were performed on the rotary vertical drilling machine previously referred to. Fig. 4 illustrates the set-up used in the fifth operation — contour-milling the piston end of the rods. It will be noted that in this set-up the lower end of the cutter was supported by a bearing in a bracket that was bolted to the spindle saddle. While the cut was being taken the piston end of the rod was moved around. A clamping

bracket of the same general type as the one that was used on the horizontal milling machine fixtures was employed.

The cutters used were 5 inches in diameter, 12 inches long, and of the helical inserted-tooth high-speed type. The cutter speed used was 35 feet per minute, and a rate of table revolution equivalent to a feed of 1½ inches per minute. The depth of cut was ⅜ inch, and the width 10⅜ inches. The time required for machining two forgings was one hour and forty-five minutes.

MILLING LOCOMOTIVE MAIN RODS AND MAIN ROD STRAPS

	Operation No.	Operation	Table Feed, Inches per Min.	Cutter Speed, Feet per Min.	Depth of Cut, Inches	Total Width of Cut, Inches	Total Cu. In. Metal Removed per Min.	Horsepower per Cubic Inch	Production Time, Floor to Floor
Main Rods Alloy Steel—Heat-treated	1	Slabbing (both sides)	3	33	19/32	23	41	1.45	3 hr. 28 min. (2 forgings)
	2	Drill hole	....	....	.....	.....	....	....	(2 forgings)
	3	Edging (both edges)	3	33	11/16	20¾	41	1.38	3 hr. 42 min. (4 forgings)
	4	Channeling (both sides)	5½	58	1 9/16	†	58.6	1.13	5 hr. 10 min. (2 forgings)
	5	Mill end contours	1½	35	⅜	10⅜	....	....	1 hr. 45 min. (2 forgings)
	6	Mill strap end	1	35	⅜	11	....	....	1 hr. 45 min. (2 forgings)
	7	Mill for brasses (2 cuts)	¼ R* 1½ F*	50	⅛ F*	10⅜	....	1.7	4 hr. 30 min. (2 forgings)
Main Rod Straps Alloy Steel—Heat-treated	1	Slabbing (both sides)	4½	52	⅜	12	....	....	2 hr. 6 min. (2 forgings)
	2	Mill exterior (except radius)	1½	53	⅜ to ½	5½	....	....	1 hr. 25 min.
	3	Mill interior (except radius)	1½	50	⅜ to ½	5½	....	....	1 hr. 19 min.
	4	Mill inside corners	....	50	... ..	5½	....	....	50 minutes
	5	Mill outside corners	....	53	.....	5½	....	....	48 minutes
	6	Mill around lug	....	50	.....	5½	....	....	39 minutes

Machinery

*R, roughing cut; F, finishing cut. †First cut, 3¼ inches; second cut, ¾ to 1¼ inches.

The sixth operation consisted of milling the strap end of the rods, using practically the same set-up as that illustrated in Fig. 4. The cutter speed was 35 feet per minute; rate of feed, 1 inch per minute; depth of cut, ⅜ inch; and total width of cut, 11 inches. The production time was one hour and forty-five minutes for two forgings.

The final operation on the main rods consisted of milling out the piston end to accommodate the brasses and wedges, as shown in Fig. 5. Two rods were supported from a monorail hoist, which is part of the machine, and securely clamped together in alignment at the outer end and properly secured to the table at the piston end. A solid helical milling cutter, 2 inches in diameter, was used in this operation. The cutter was supported at the end by a bearing bracket. Two cuts were taken—a roughing cut, with a feed of ¼ inch per minute and a finishing cut, with a feed of 1½ inches per minute. For both the roughing and finishing cuts, the cutter speed was 50 feet per minute. In the finishing operation, which is that illustrated, the depth of cut was ⅛ inch, and the width 10⅜ inches. The horsepower required per cubic inch of metal removed was 1.7. The floor to floor machining time was four hours and thirty minutes for four cuts, two per rod.

Machining Main Rod Straps

Six milling operations were performed in machining the main rod straps, and the forgings were handled on machines of the same type as those on which the main rods were milled. The slabbing operation is illustrated in Fig. 6, which shows two rough forgings being slabbed. This illustration also gives an excellent idea of the method of securing the work. In the slabbing operation, two helical inserted-tooth milling cutters, 9 inches in diameter and 24 inches long, were used, operating at a speed of 52 feet per minute. Although these forgings were rough, the amount of scale was considerably less than in the case of the main rods, so that it was possible to increase the cutter speed, and also to increase the table feed from 3 to 4½ inches per minute. The depth of cut was ⅜ inch, and the width, except for the projecting lug on the side of the strap, 12 inches. The time required to slab both sides of two straps was two hours and six minutes.

The second milling operation consisted of machining the

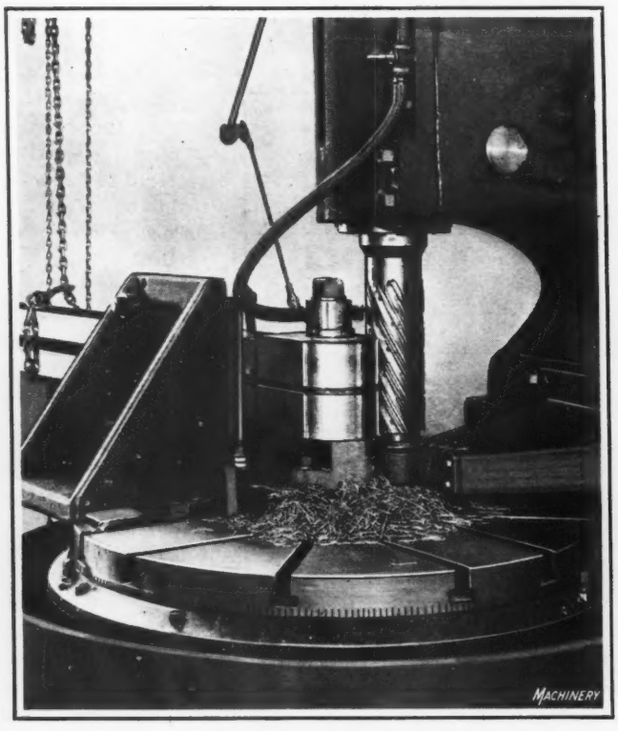


Fig. 4. Milling the Contour at the Piston End of the Rods

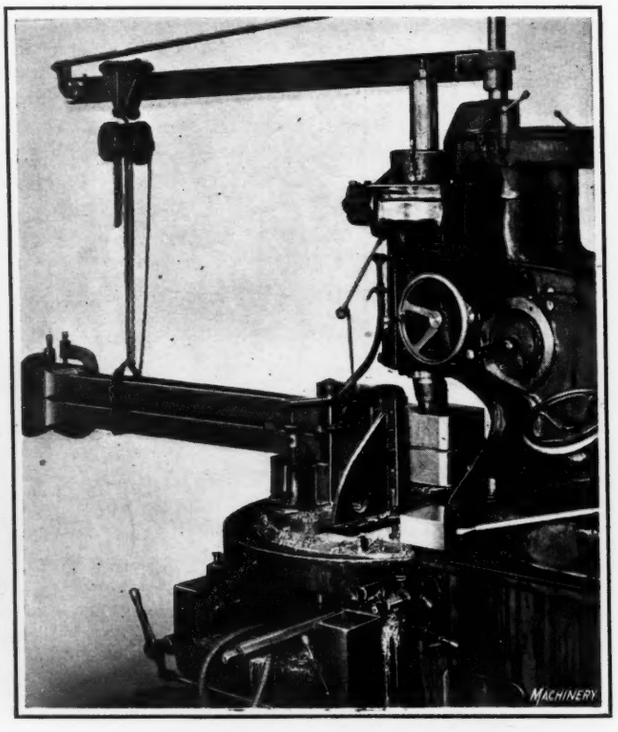


Fig. 5. Finish-milling the Piston End of the Rods

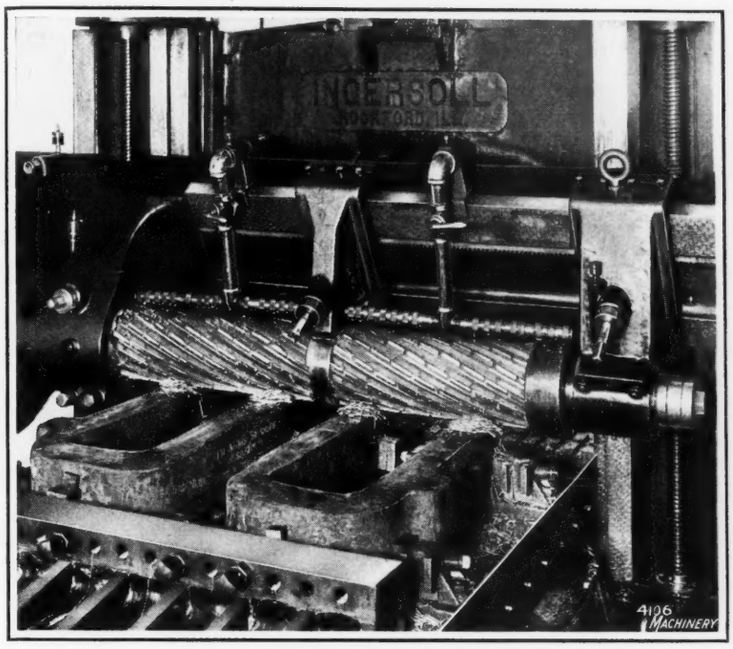


Fig. 6. Slab-milling Locomotive Main Rod Straps

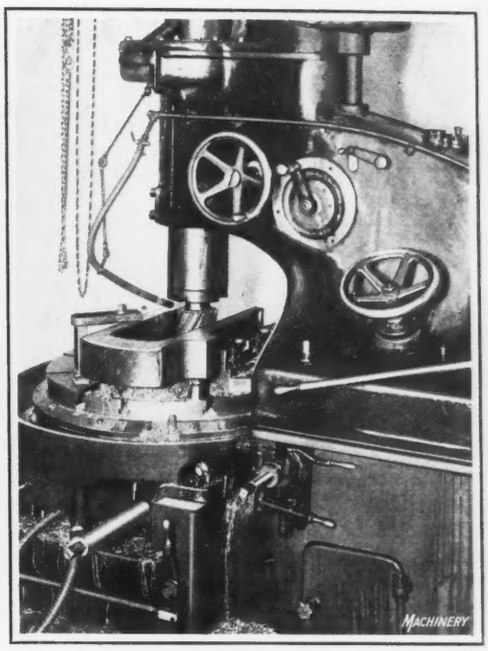


Fig. 7. Milling the Inside Surfaces

exterior surfaces, except those having a radius of less than 6 inches. This work was done on a vertical rotary machine with the work simply strapped to the platen, in the same manner as shown in Fig. 7. The data for this operation are as follows: Size of cutter, 6 inches diameter, 6 inches long (helical inserted-tooth); table feed, 1½ inches per minute; cutter speed, 53 feet per minute; depth of cut, ⅜ to ½ inch; width of cut, 5½ inches; and machining time per forging, one hour and twenty-five minutes.

The next operation consisted of milling the inside of the straps, except the 2-inch radius at the corners. This set-up is illustrated in Fig. 7. The machining data for this operation are practically the same as for milling the outside of the straps, except the machining time which is one hour and nineteen minutes. The set-up for finishing the inside corners of the straps to a 2-inch radius was similar to that shown in Fig 7 except that a solid type helical cutter, 2 inches in diameter, was used, and the machining time for this job was fifty minutes per operation.

The next milling operation which is the fifth in sequence, consisted of milling the outside corners, which have a 2½-inch radius. For this work, a set-up similar to that employed for the third operation was used. The cutter was 4 inches in diameter, of the helical inserted-tooth type, and operated at 53 surface feet per minute. The time required to machine two corners on each strap was forty-eight minutes, floor to floor. The last milling operation was machining the 2-inch radius around the exterior lug, as illustrated in Fig. 8. Here a 2-inch diameter solid helical cutter is shown in use, with its lower end supported in a bearing. The cutter speed was 50 feet per minute, the width of cut, 5½ inches, and the machining time, floor to floor, thirty-nine minutes for milling the two corners of each lug. For convenient reference, the data obtained as a result of the Ingersoll tests are presented in condensed form in the accompanying table.

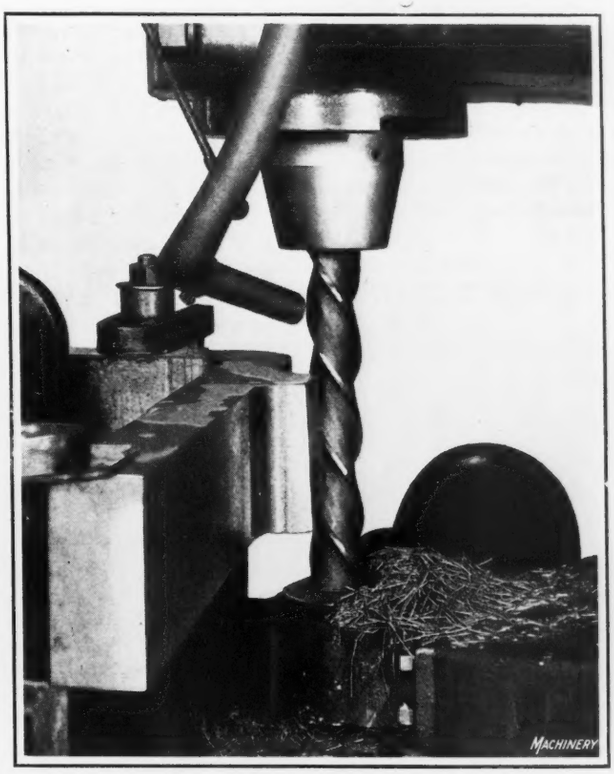


Fig. 8. Rounding the Corners of an Exterior Lug on the Straps

* * *

EYE INJURIES IN THE INDUSTRIES

The number of accidents resulting in workmen's losing one or both eyes is very great and strenuous efforts have been made to reduce them through the use of goggles. A great deal of experimenting has been done to secure satisfactory glass for goggles, and to produce designs that would meet all objections. Nevertheless workers generally are not favorably inclined toward the use of goggles. It appears that there is a slackening of attention to safety provisions in many industrial plants, and recent publications of the organizations interested in accident prevention have stated that safety provisions and insistence on the use of safety appliances have been discontinued in many places, and that the working conditions have been allowed to drift into the careless methods of former years. This is to be regretted, and while a great deal of it is due to the attitude of the worker who is likely to become indifferent to the dangers of his occupation, the management of industrial firms must continue to be vigilant and to bring pressure to bear to insure that safety appliances will be properly used.

OCTOBER, 1922 **MACHINERY** VOL. 29 NO. 2

PUBLISHED MONTHLY BY THE INDUSTRIAL PRESS, 140-148 LAFAYETTE ST., NEW YORK

ALEXANDER LUCHARS, PRESIDENT
MATTHEW J. O'NEILL, GENERAL MANAGER
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STANDARDS FOR ROLLER BEARINGS

Referring to the value of standardization in the automotive industries, B. B. Bachman, president of the Society of Automotive Engineers, lays great stress upon the necessity for proceeding in a rational way "to extend and continue the standards work which was inaugurated about twelve years ago, and which has been carried on continuously since. Cooperative endeavor of this kind is vitally essential."

Among the many things that the Society of Automotive Engineers is endeavoring to standardize are the dimensions for tapered roller bearings, on which a committee has been at work for some time. Ball bearings have been standardized so that the number of sizes available are limited to what is considered essential for the needs of the industries. Work is also progressing on standardizing straight roller bearings, a subject of equal importance. In the tapered roller bearing field there are now over 200 sizes used in the automotive industry, and it is believed that about 50 sizes would probably care for practically all requirements. It has been suggested that possibly the sizes could be so determined that tapered roller bearings would be interchangeable with the already standardized ball bearings.

This work is of great importance, and while it is evident that as the work of standardization proceeds, a great many differences of opinion will be encountered, there is no doubt that standards can be established that will meet the requirements of all. It may appear at times that too rigid standardization might be unwise, and might result in harmful restriction of initiative in the design and development of mechanical devices. Nevertheless, when standardization methods are not too drastic, they will always be found of value to the industry. Great savings in manufacture and in distribution will result, the methods of manufacture can be simplified, the range of sizes that have to be kept in stock can be reduced, the capital investment of manufacturers and dealers will be less, and the ultimate consumer will be able to buy a standardized product at a price much lower than that of a product where the number of types or sizes made is far in excess of actual needs.

* * *

TOOL STEEL SOLD ON A SERVICE BASIS

When a customer buys pig iron or structural steel, he buys so many tons of steel and pays for it, and there the transaction ends; but when a user of tool steel buys, it is not exactly so many pounds of steel he wants to acquire—it is the service of a tool steel to be used as a cutting tool. The value of steel to the buyer cannot be measured in pounds, but in performance. In this respect, tool steel as a product is in the same class as machine tools. The machine tool buyer is not seeking so many hundred pounds of cast iron and steel. What he wants is the reliable service of a machine that will perform certain work of a given quality in a given time. The same with tool steel—its value depends entirely upon its performance in cutting metal. If it does not stand up as required under a cut, the seller is sure to hear from the buyer. If it fails to respond properly to heat-treatment, the steel manufacturer will be asked to tell how his steel can be heat-treated to give maximum performance. With steels of good quality, the best results depend, of course, upon adequate heat-treatment.

Naturally, the price of tool steel should also be governed by its performance—in speaking of tool steel in this general way, high-speed steels, of course, are included. Composition or analysis alone does not determine the merit of a steel. It is possible to make two steels of exactly the same analysis, and yet one may be far superior to the other in cutting qualities. That is why firms that specify chemical analysis only are sometimes able to buy tool steel at a very low price. It is much easier for the steel manufacturer to make a steel of a given analysis than to make a steel that will measure up to certain performance requirements.

Users of tool steel who realize that they are buying steel, not by the pound but for service, will find that by insisting upon service rather than analysis they will get more actual value for their money. Manufacturers of tool steel and high-speed steel are able to render service to those who are able and willing to cooperate with them by stating exactly what their requirements are. More and more this becomes the modern idea of business—to sell not merely goods, machines, devices, or tools, but, in principle at least, to sell service.

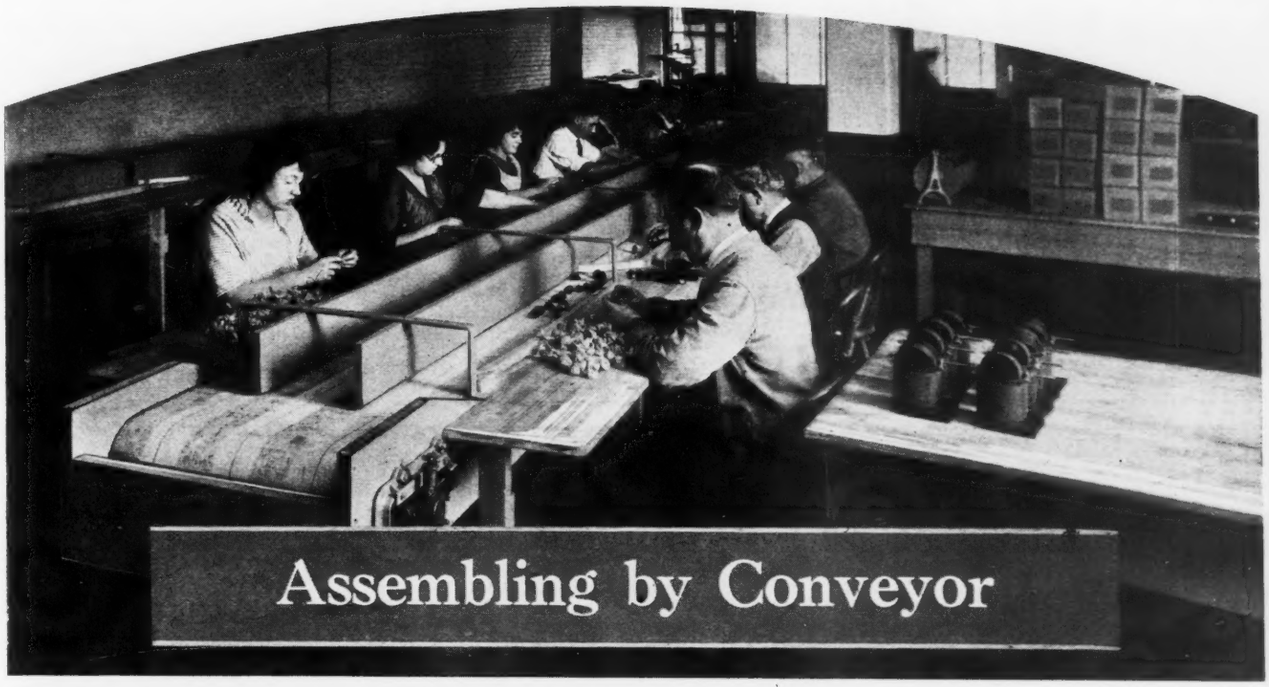
* * *

THE HIGH-DUTY MACHINE TOOL

The introduction of a new machine or method is a slow process. High-duty, high-production machine tools are not yet fully appreciated by many manufacturers employing tool equipment. Few industries have taken advantage of the improved machine tools placed at their disposal during recent years to the extent that the automobile industry has, and as a result, the cost of its product has been reduced. In many other branches of the machinery industry we still find machine tools of obsolete types, with no capacity for steady high production. They continue to cut metal, but the speeds and feeds and other features do not compare with up-to-date machines. These faithful servants are steadily losing money for their owners, but there seems to be no desire to part with them.

The foreman of a shop using a line of lathes about twenty years old, questioned about the continued use of machines built before the days of high-speed steel, answered: "Well they are doing their share, with a little patching up every now and then." His superiors apparently were of the same opinion, or they would have replaced this equipment long ago. "Their share" was a very small one compared with what a new high-duty lathe could do; and the "patching up every now and then," over a period of years, probably cost almost as much as new machines.

The scrapping of worn-out or out-of-date machine tools and their replacement by new machines of greater capacity would usually save the buyers of shop equipment money. This is especially true of railroad shops but similar conditions will be found in many shops manufacturing pumps, steam engines, conveying machinery, and textile machinery, to mention but a few of the lines of manufacture in which there has not been so universal an application of modern machine tools as in the automobile industry. Prices of machine tools are as low now as they are likely to be for years. Eliminate the money-wasting machines that handicap you in competition, and get ready for the good times just ahead.



Assembling by Conveyor

A Recently Developed Assembly System for Increasing Production and Reducing Manufacturing Costs

By WARREN ORDWAY, The Lamson Co., Syracuse, N. Y.

IN the manufacture of a large class of products such as carburetors, meters, radio parts, lighting fixtures, etc., the cost of the material is negligible, as compared with the cost of manufacturing the component parts and assembling them. In some cases the assembly cost amounts to as much as 50 per cent or more of the total cost. A great deal of attention has been given to developing automatic machinery for turning, stamping, or casting small parts in quantity, but until recently the assembly has usually been done by the same old-fashioned bench methods that have been in use for generations.

The present article will show the application of conveyors in assembling systems, whereby the old bench system is eliminated and the assembly of light units made as quick and easily controlled as the manufacture of the parts entering into their construction. This new system is applicable to practically any assembly operation as well as to filling containers with liquids, inspecting, packing and boxing, and a hundred other uses. One advantage of the system here described is that it can be installed in an old plant as well as in a new one. The mechanical equipment required can usually be built around the existing production system without requiring serious changes in plant lay-out. Two typical installations are described in the following — one at the plant of the Moto-Meter Co., Inc., Long Island City, N. Y., makers of the Boyce "Moto-Meter" and the other at the plant of Mitchell & Co., Boston, Mass., makers of radio equipment.

Fig. 1. Assembling "Moto-Meters" by the Conveyor Method; Cleats bored to hold Two Meters are attached to the Belt

Assembling "Moto-meters" by the Conveyor System

If Cadillac or Studebaker should wire to the Moto-Meter Co. for a thousand moto-meters, with special nameplates, it is probable that the order would be filled the same day, or at the latest by the next day. It might be imagined that to give such service as this an enormous stock of finished meters would be required, as there are seven separate models, and about 145 different types of nameplates that are in constant demand. But if a supply were kept in stock of the many hundreds of different combinations of models and nameplates which would be required to fill any order that might be expected, a great deal of capital would be kept tied up in finished goods.

As a matter of fact, that is the way the business was handled up to a few months ago. The finished stock amounted to about 160,000 meters. Today 100,000 fewer instruments are required in finished stock, and deliveries are made even more promptly than before. This remarkable achievement has been obtained by the installation of the conveyor system of assembly designed and built by the Lamson Co., Syracuse, N. Y. Before the installation of the conveyor system, the method used was one that is quite generally practiced in many plants today.

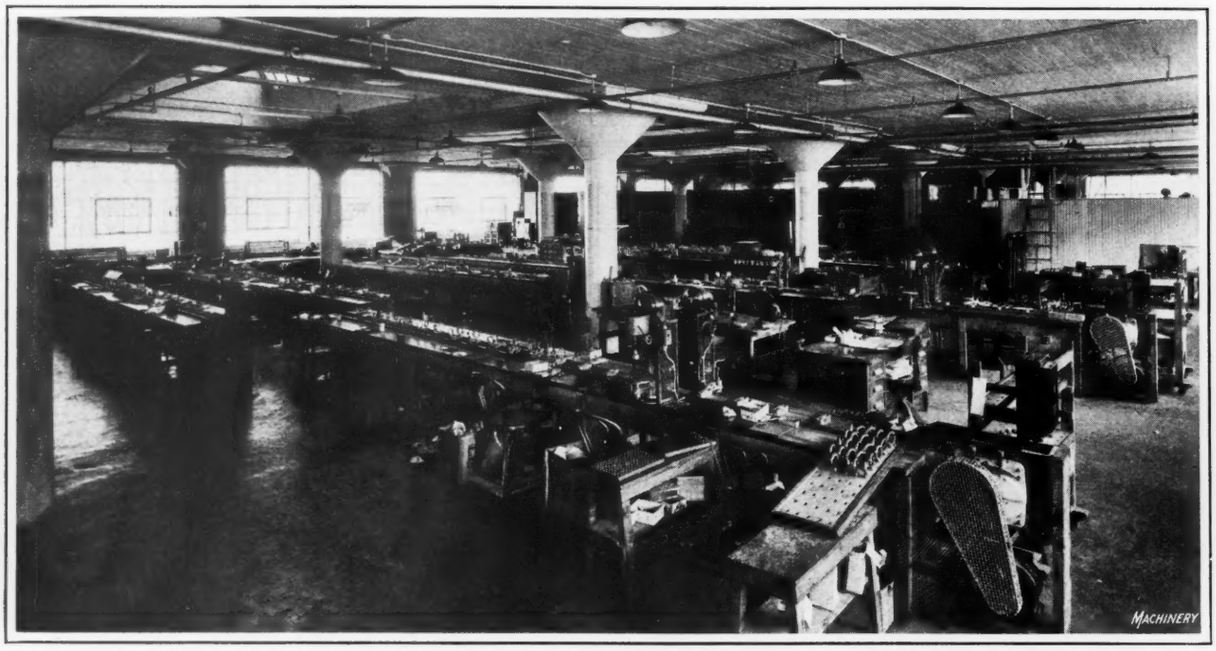


Fig. 2. General View of the Assembling Department of the Moto-Meter Co., showing the Large Number of Conveyors used

The meter frames came from the finished materials stock room on trucks holding six trays of fifty meters each, and passed from operation to operation on them.

There were about 100 trucks and 100 assembly tables measuring 4 by 2 feet at which the various assembly operations were performed. Besides taking up a great deal of space, and cluttering up the room with tables and trucks, this system required three or four days to finish an order, and tied up 20,000 instruments on a production schedule of 5000 per day. The workers found it hard to perform their tasks efficiently, as they were constantly interrupted by having to lift the trays of instruments on and off the trucks, and push the trucks about between the assembly tables.

Conveyors Adapted to Existing Production System

The conveyor system was built around this older production system without interfering with the methods of assembly which had been found satisfactory. The conveyor system is built in three units of three conveyors each, which carry the instruments past the various workers in the assembly line. The frames are started at one end, and the various parts are added as they pass along the conveyor, till at the discharge end, the finished, inspected, and boxed instruments are delivered ready for shipment.

The first operation is putting the frame together. This task is given to a girl who is chosen for her speed and alertness, as she sets the pace for the entire assembly operation. Once a frame is started along the line it must go through every process at the predetermined rate of production. Any slowing up of any operation causes the instruments to pile up, and is immediately seen and remedied. Besides insuring greater and more uniform production, this conveyor system makes the task of supervision far easier, as the conveyor itself serves as a pace-setter for every task.

There are six operations performed along the first conveyor: (1) putting the frames together; (2) rolling in the cap over the tube; (3) cementing in the thermometer; (4) scraping off superfluous cement; (5) enameling the back of the tube; and (6) inspecting. After the first inspection, the meters are sent down two conveyor lines, where the following operations are performed: (1) Back assembly; (2) front assembly; (3) final inspection; (4) packing; and (5) sealing and packing in cartons.

As indicated by the illustrations, the system consists of belts driven by electric motors; the belts are 6 inches wide with wooden cleats, bored to hold the moto-meters upright. The instruments are easily removed from the belt, and as easily slipped back into these bored cleats. The belts are driven at slow speed (from about 5 to 10 feet per minute) which can be varied to give any capacity desired. In an assembly line of this kind, however, a comparatively slow belt movement gives ample carrying capacity for the largest production the operators can turn out.

Speed and Flexibility of the System

The chief advantage of the conveyor system of assembly is the speed with which orders are put through and the consequent cutting down of stock in process and finished stock. In the plant of the Moto-Meter Co., the conveyors have cut down the time necessary to fill an average order from four days to considerably less than a day. This means that most orders can be filled the day they are received from semi-finished stock. The stock in process necessary for a production of 5000 instruments a day has been cut from 20,000 to 7500. The finished stock, as has been previously described, has been cut down from 160 000 to 60,000 instruments, with even better service to customers than before.

Savings of Labor and Space Due to Conveyor System

In addition to these savings, the savings in labor amount to 15 per cent, and would pay for the entire system in about two and one-half years. This greater labor efficiency comes from saving the girls' time by eliminating the moving about of trays and racks of product, and from the pacemaking feature of the conveyor, which insures steady and uniform production. As all unnecessary hand and body movements of the operators are done away with, they do their work with much less fatigue, and turn out an increased production with much less effort than previously.

The space saved by the system is also considerable. Each assembly table formerly used occupied 4 by 2 feet, and the trucks were bulky and required considerable aisle space. Compared with this, the conveyor system occupied only a fraction of the space, and every square foot is put to productive use. The wear and tear on the trucks and the floor, while hard to compute, is also an item which becomes fairly large during the course of a year.

Effect of System on Operators

A great deal has been said about the objection of labor to new labor-saving machinery, and particularly to machinery that sets a pace in regard to working speeds. This

objection has not been found to apply in the Moto-Meter plant in regard to the assembly conveyor system, because the assemblers, while they are enabled to turn out more work than under the old system, can do it with much less physical labor and fatigue. The conveyors save them all the heavy work of lifting the trays of instruments and pushing about cumbersome trucks, and leave them only the lighter work requiring their particular skill.

Assembling Radio Parts by the Conveyor System

The experience of Mitchell & Co., Boston, radio equipment manufacturers, may prove of value to any company whose problem is that of increasing production without a corresponding increase in equipment and personnel. This company used conveyors to obtain a bigger share of the flood of radio business in the early part of this year than they could otherwise have obtained. Although the conveyor system used by this company is moderate in size and in first cost, C. R. Dumble, chief engineer of the company, states that it has increased the production per worker five times, and the production from a given area of floor space ten times.

Before the conveyor system was installed, assembly was done in the usual way on tables, each operator putting together complete the various items handled. The floor space required was large, and the production was low, as it was difficult to check the work of each assembler. The rejections, too, were large enough to be quite an item of expense. Under the conveyor system, every job is broken up into a number of individual operations, each one of which is performed by one or more workers. The work is done on a moving conveyor which carries the parts from operation to operation, and takes the finished and boxed product to the stock-room.

Construction of Conveyors

There are two conveyors, 24 inches wide and 46 feet long, which are electrically driven at 90 feet per minute. Each conveyor has two partitions running its entire length, which virtually divides the belt into three 8-inch belts. The two outside partitions are used to carry the parts between operations, while the central section carries the boxed product to storage. The outside belts are equipped with movable switches, one at each operator's place which throws the parts out on the assembly benches located on each side of the belt. These switches provide a very flexible arrangement. They can be set to deliver from each operator to the next, or, where two or more operators perform one operation, they can be thrown in and out of position as each operator desires more material to work on.

Assembling Radio Switches

A good example of what the system accomplishes is found in the assembly of radio switches, one of the specialties of the company. Eight operators are required who perform the following operations: (1) Remove paper from knob; (2) screw blade or insert; (3) put shaft on insert; (4) tighten shaft; (5) and (6) put on bushing, spring, and nut; (7) inspect, wrap, and put in box; (8) put on cover and place on belt. Composition knobs are brought to the worker at the first operation about once an hour. Most of the other parts are so small that a box of them under the conveyor, will last all day. The paper packing boxes which come to the packer are carried on a narrow conveyor discharging from a hopper over the conveyor table.

In the operation of the system, the various tasks require different degrees of speed and application. The system is therefore run in continuous half-hour shifts, with short rest periods between, the operators being moved after each rest period. In this way a girl who packs for a half hour—a task requiring great speed and accuracy—may remove the wrappers from the knobs during the next period—the easiest task on the conveyor line. This moving from task to task makes for a more flexible organization and relieves the monotony of doing one small operation all day long. The pacemaker for this system is the fourth operator who tightens shafts. On this task a skilled male operator is employed continuously.

The Feature of Automatic Supervision

This system practically does away with any need of supervision. Each operator, while the belt is moving, must keep her work up with the rest, or else her parts will stack up and at once become noticeable. The first operator, while not serving as a forewoman, acts as a "flywheel of production" and irons out any irregularities of output that may occur along the line, by helping out the girls who are behind. The effect on the workers is also remarkable, as shirkers are automatically eliminated. The earnings of the employes are also greater than under the ordinary assembling methods, as piece-work prices can be so set as to permit of a bigger daily wage. The inspection, too, is practically automatic. Each operator becomes virtually the inspector of the work of the previous operator. The high quality of this consecutive inspection is evident from the fact that out of 50,000 of a certain type of switches manufactured, there is said to have been but one defective unit.

The production with conveyors has been increased fivefold. Under the old plan, four operators, at benches, turned out 300 switches complete per hour. With the conveyor

Fig. 3. A View of the Assembling Department, showing Conveyors with Operators at Work

eight operators can easily complete 3000 switches in an hour. The space required is only one-tenth of what was needed with the tables for an equal production. Four people required a floor space of 10 by 18 feet for 300 per hour, while about the same space is sufficient to turn out 3000 per hour with the conveyor. Three thousand boxes of finished switches alone, representing one hour's work, would

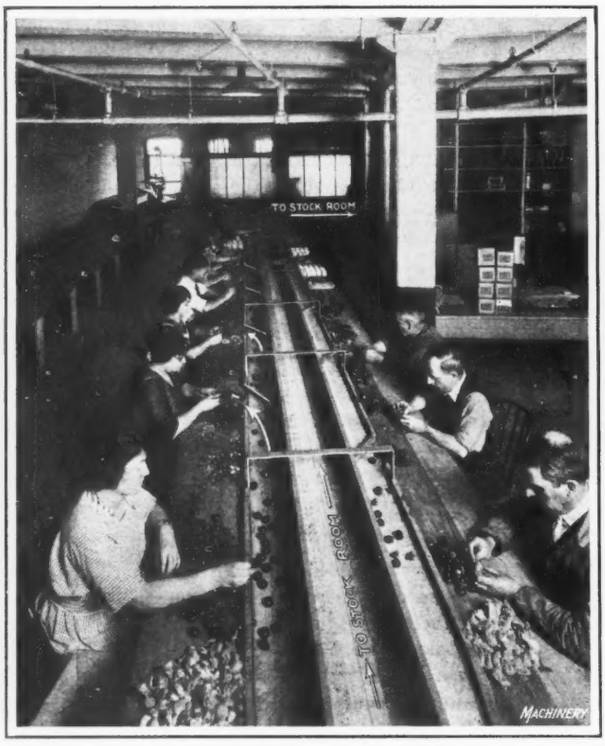


Fig. 4. Assembling Radio Apparatus by the Conveyor System

pile up 20 feet of table 4 feet wide, while with the conveyor they are in the stock-room almost as soon as complete. This is a very important advantage with rents as high as they are today, and in itself will pay for the conveyor in a few months' time. The speed of the new system is self-evident. Orders that formerly required several days to fill can now be shipped the day the order is received.

Assembling Automobiles by the Conveyor System

One of the most familiar applications of the conveyor system of assembling and one of the earliest to be worked out, is the consecutive assembly of automobiles. The Lamson system used by the Franklin Motor Car Co., Syracuse, N. Y., is a good example. Here the chassis is assembled along a conveyor running the length of the department, the wheels are put on as the chassis passes across one end, and the body is put on and finished as the automobiles are carried down a conveyor parallel with the first. Although the workmen were changed from a piece-work to a day-work basis when this conveyor was installed, the production was increased to such a point that the daily quota of cars was turned out with about 20 per cent fewer employes.

An interesting story is told about this conveyor. Owing to a break in the power line, it was put out of service for an hour or two one morning. During the afternoon, the conveyor was speeded up enough to complete the daily quota of cars, and the workmen made up the lost production without knowing what was going on until they were told about it at the end of the day.

The conveyor systems described are typical of those used in various plants making machines or apparatus from metal or wood. Numerous other applications could be cited, as in cash register manufacture, lighting and starting sets in automobile manufacture, etc., but the examples shown indicate the general application of the conveyor system of assembly.

CONVENTION OF THE SOCIETY OF INDUSTRIAL ENGINEERS

The Society of Industrial Engineers will meet for its ninth annual convention at the Hotel McAlpin, New York, October 18 to 20. At the opening session at 3:00 P. M., Wednesday, October 18, Joseph W. Roe, president of the society, will speak on "The Relation of Economics to Industry."

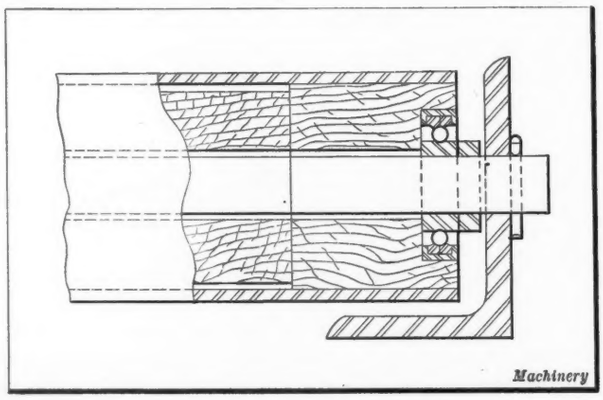
"The Economic Background Necessary for a Business Executive," is a topic that will receive special consideration at a general meeting of the Educational Group on the first day of the convention. At another meeting, Ernest F. DuBrul, general manager of the National Machine Tool Builders' Association, will present a paper on "The Economic Aspect of Production." Arthur J. Todd, director of labor, B. Kuppenheimer & Co., will deliver a paper on "The Industrial Age." A. J. Lutterback, comptroller, Palmolive Co., will speak on "The Budget and the Financial Forecast."

At the banquet, three other speakers of note will address the convention—F. H. Sisson, vice-president, Guaranty Trust Co.; D. R. Dewey, Massachusetts Institute of Technology; and Royal R. Keely. Mr. Keely has recently returned from two years engineering work in Russia. He is an industrial engineer and will speak on "The Industrial Situation in Russia." The Friday evening session is to be devoted to the subject "The Application of Material Handling for the Purpose of Reducing Costs and Increasing Production." There will be an interesting exhibit of material-handling equipment, as well as other factory and office equipment.

* * *

ROLLER FOR GRAVITY CONVEYOR

Gravity conveyors of the roller type are used in automobile and other manufacturing plants for assembling various units, and are often subjected to severe service in handling the heavier parts. At the plant of the Studebaker Corporation the experience has been that pressed-steel and cast-iron rollers are unsatisfactory for conveyors used in assembling such units as the motor and, as a consequence, in new conveyor installations this company is using rollers of the design illustrated. The roller consists of a steel tube 2½ inches outside diameter and 5/32 inch thick, which is backed up by a hard-wood core that extends the length of the tube. At each end of the hardwood core is a Schatz



Gravity Conveyor Roller with Hard-wood Core and Steel Outer Surface

annular ball bearing. The inner race of the bearing rests on the round bar which supports the roller in the angle-iron of the conveyor frame. This angle-iron is 2 by 3 inches. The round bar of the roller is held in place by means of cotter-pins. These rollers are made in various lengths to suit conditions.

* * *

The production of automobiles and trucks in the United States for the eight months ended August 31 was about 1,660,000 cars, compared with 1,668,500 cars for the entire year of 1921.

Can Tapered Roller Bearings be Run at High Speeds?

By T. V. BUCKWALTER, Chief Engineer, The Timken Roller Bearing Co., Canton, Ohio

It is generally believed among engineers and shop men that tapered roller bearings are not suitable for bearings running at high speeds—that is, at 3000 revolutions per minute and over. This belief is so firmly established in the minds of many well informed technical men that it has been deemed advisable to place on record the results obtained in running tapered roller bearings economically and efficiently at speeds exceeding not only 3000 revolutions per minute, but 10,000 revolutions. When it becomes thoroughly appreciated that tapered roller bearings can be successfully used for high speeds, an entirely new field will be opened up for the application of these bearings. Their advantages in machine construction will lessen operation costs in machine shops and other industrial plants. There are some applications for which it appears that no other type of bearing is quite as satisfactory as a roller bearing, and for that class of service there will be an opportunity to save in maintenance expense.

PERFORMANCE records of tapered roller bearings over as many as ten years in the plants of important manufacturers have proved conclusively that tapered roller bearings will carry heavy loads efficiently and economically at continuous speeds as high as 11,500 revolutions per minute. The term "high speed" is generally applied to machines operating at 3000 revolutions per minute and over, including grinding and buffing machines, motors and certain special-purpose machines. The bearings in the transmissions and pinions of many automobiles operate at speeds in excess of 3000 revolutions per minute, which is only a medium speed, it is true, in comparison with the much higher speeds of many kinds of industrial machinery. But the transmission or pinion bearing, although operating at only 3000 revolutions per minute, is actually subjected to more severe service than the industrial machine bearing operating at a much higher rate, for the simple reason that the automobile bearing transmits more power and consequently carries a heavier load.

Experience of Users of Tapered Roller Bearings Operating at High Speeds

It is not surprising, considering its conspicuous success in automotive service that the tapered roller bearing is giving such a good account of itself in the faster, but less severe, service met in industrial machinery. The experiences of users of tapered roller bearings operating at high speeds will no doubt be of interest, and therefore a number will be cited in this article.

One manufacturer states that before using tapered roller bearings in his buffing, polishing, and spinning lathes, the bearings required four complete replacements a year, the average bearing life being about three months. Since changing to tapered roller bearings two years ago no replacement has been necessary, the bearings still functioning as well as when new and no wear being apparent. During this time the lathes have operated continuously at 3400 revolutions per minute nine hours per day.

A technical instrument manufacturer, using a well-known polishing lathe, replaced the bearings furnished by the lathe manufacturer with tapered roller bearings. After fifteen months of service at 4350 revolutions per minute for eight hours per day, the tapered bearings were found to be in good condition and adjustment was unnecessary. This manufacturer states that with the bearings formerly used two entire replacements would have been required.

A manufacturer of polishing machines operating at speeds up to 10,000 revolutions per minute, has equipped his machinery with tapered roller bearings since 1911, and has never received a complaint of bearing failure from his customers. He states that on direct motor-driven polishing machines having the wheels mounted on the armature shaft, the tapered roller bearing is ideal, especially with alternating-current motors, because it holds the rotor central and prevents it from dragging on the stator and burning out the windings.

A large automobile manufacturer has placed tapered roller bearings from his regular stock in grinding machines of his own design and manufacture. His internal grinding machines operate at a speed of about 16,000 revolutions per minute. According to the production manager, the advantage derived is the reduction of the maintenance force on grinder spindles to about one-third that required when the spindles were equipped with plain bearings.

Another large automobile manufacturer is introducing tapered roller bearings in a general line of machinery of his own design and manufacture. Some of the grinding machines operate at a speed of 11 500 revolutions per minute. A manufacturer of automobile accessories has also introduced tapered roller bearings in grinding machinery of his own design and manufacture, the spindles of which run at 7000 revolutions per minute.

Conclusion

The facilities for the production of tapered roller bearings might almost be said to have been commandeered by the automotive industry until within recent months. The application of these bearings in the mechanical field within the last ten years, therefore, has been largely voluntary with manufacturers. Notwithstanding this conlition, there are upwards of 400 applications in the mechanical field in a wide variety of loads, speeds, and kinds of service. This general success has prompted a leading manufacturer of tapered roller bearings to organize for a more general introduction of the tapered roller bearing to the mechanical field.

* * *

PACKING FOR EXPORT

The Bureau of Domestic and Foreign Commerce has often pointed out the importance of proper packing for export. It is stated that frequently American manufacturers do not pack any more securely for export than they do for domestic shipments. As a specific example, in one shipment of nuts and bolts contained in wooden kegs, 80 per cent of the kegs burst when they were lowered from the ship into lighters, the contents being scattered all over and having to be shoveled into bags and later sorted out by hand. European exporters, it is stated, use sheet-iron containers, which are greatly to be preferred. One European firm recently secured an order for fifteen tons of rivets by cable because an American concern disregarded the instructions to ship in double bags of heavy material, which, while not as good as sheet-iron kegs, nevertheless are greatly superior to wooden containers.

Tests on Anti-friction Lineshaft Bearings

By J. F. McGUINNESS, Directing Transmission Engineer, Hyatt Roller Bearing Co., New York

TO the manufacturer whose main object is to operate his plant on the most efficient basis, the merits of a new or improved piece of machinery are founded entirely upon the actual saving derived from its use. If, by comparison with the equipment it replaces, the difference in power consumption, labor, production and maintenance is sufficient to pay for the new machine within a reasonable period—say one year—the purchase of such equipment is considered an attractive investment. When E. I. du Pont de Nemours & Co., one of the country's largest power consumers, took up the question of using anti-friction bearings on lineshafting as a means of reducing power consumption, the engineers in charge of their power transmission department approached the subject with the single idea of determining the investment value of anti-friction equipment. This department, supervising the transmission of power throughout the duPont organization, could not report favorably on the anti-friction idea without first giving it a thorough test under practical working conditions.

In looking about for an installation of maximum severity (one termed a hard drive) a double-shaft drive was selected in the sulphonating house connected with the dye plant at Carney's Point, N. J. At that time this shafting was equipped with twenty-eight ring-oiling bearings, the sizes being 2 7/16, 2 15/16 and 3 7/16 inches. This shafting transmitted power to large vats containing paddles, which agitated heavy and somewhat viscous liquids used in the manufacture of dyes. The plant was operated on a twenty-four hour per day basis continually.

In order that the test of both the ring-oiling bearings and the anti-friction bearings could be conducted under conditions as nearly alike as possible, it was decided to run both tests the same day. A corps of engineers, therefore, in charge of William Stanier, chief transmission engineer of the duPont organization, set up the necessary instruments consisting of a wattmeter, an ammeter and a recording wattmeter. The actual test of power consumption with the shafting running in ring-oiling bearings was begun at 10:00 A. M. and consumed altogether one hour and forty-five minutes. During the test, readings were taken at full load, the lineshaft running with the countershaft belts disconnected and with the motor running idle.

The anti-friction bearings were of the flexible roller, split type, and these were substituted for the plain bearings without removing pulleys couplings or collars. Four millwrights, each one aided by a helper, made this change, the average time required to remove one ring-oiling bearing and set in place one roller bearing being about six minutes. After the roller bearings had been oiled and allowed to run for a half hour, the power consumption of the shafting equipped with roller bearings was recorded, the same combinations of drive being used as during the ring-oiling test. The figures recorded as a result of these tests are as follows:

Type of Bearing Tested	Power Consumed
Ring-oiling bearings	31.3 H. P.
Roller bearings	26.8 H. P.
Saving with roller bearings	4.5 H. P.
	(or 3357 watts)

These figures show a power saving of 14.4 per cent under full load by using roller bearings. Assume that the costs are \$0.013 per kilowatt-hour for power, \$0.40 per gallon for oil and \$0.65 per hour for labor. The ring-oiling bearings are oiled once a week, but the roller bearings require attention only once every three months. The time for oiling either set of bearings averages 1.4 hours and the entire equipment consumed 1.5 gallons of oil at each refilling.

The efficiency of roller bearings from the standpoint of dollars and cents may be readily ascertained. As there is a saving of 3357 watts, the annual saving in power based upon 7200 hours, is determined as follows:

$$\frac{3357}{1000} \times 7200 \times 0.013 = \$314.22$$

Oil and oiling labor costs for the ring-oiling bearings are as follows:

Oil cost = 1.5 gal. × 52 weeks × \$0.40 per gal. = \$31.20
Labor cost = 1.4 hrs. × 52 weeks × \$0.65..... = \$47.32
Total per hour = \$78.52

Oil and oiling labor costs for the roller bearings are as follows:

$$\$78.52 \times \frac{\text{4 times yearly}}{52} = \$6.04$$

Hence, the saving in oil and labor = \$78.52 — \$6.04 = \$72.48 and the total saving by using roller bearings = \$314.22 + \$72.48 = \$386.70.

To determine the value of roller bearings as an investment, the following figures were compiled:

Cost of roller bearings.....\$654.27
Cost of ring-oiling bearings.....\$432.00
Additional cost of roller bearings.....\$222.27

$$\frac{\text{Annual saving by using roller bearings}}{\text{Additional cost of roller bearings}} = \frac{\$386.70}{\$222.27} \times 100$$

= 174 per cent

The time required to pay for the additional cost of the roller bearings equals:

$$\frac{\text{Additional cost of roller bearings}}{\text{Annual saving by using roller bearings}} = \frac{\$222.27}{\$386.70} =$$

6/10 year or 7.2 months

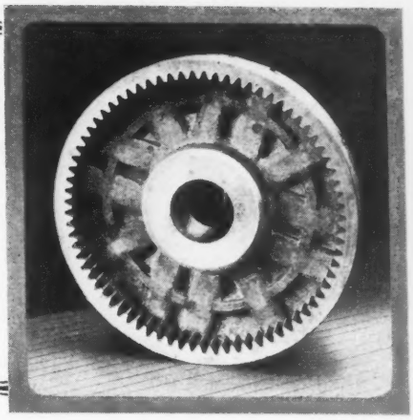
The economy resulting from the use of roller bearings on lineshafting is obtained on small installations as well as large ones. From the testimony of a number of users covering a wide variety of industries, power savings are reported ranging from 14 to 27 per cent of the total load. Considering the local conditions governing every installation, this range of savings is logical. Apart from the power-saving features of roller bearings, consideration must be given to their merit from the standpoint of endurance. Records are available showing service running from twenty years to as high as thirty years without a single item of repair or change.

* * *

In a paper recently read before the Royal Society of England by Sir Robert A. Hadfield, attention was drawn to the iron resources of the world. It has recently been estimated that if the iron output should continue to grow at the pre-war rate of increase of 5 per cent annually, the world's supply of iron would be exhausted in 150 years. It was pointed out that if China should begin to use steel in the same quantity as the United States uses it, the output of pig iron in the world would so increase that the richest sources of iron ore now known would soon be exhausted.

Strength of Internal Spur Gear Teeth

By DOUGLAS T. HAMILTON, The Fellows Gear Shaper Co., Springfield, Vt.



THE tooth action of internal spur gears is somewhat different from that of external gears, and problems are met with in designing internal gears that are not present in the other type. Several of these problems relate to the strength of the teeth. Before discussing this subject, however, it might be advisable to review briefly an improved method for determining the strength of gear teeth. The parabola scheme, which is well known, is a rather hit-and-miss method, and in order to obtain accurate results, it is necessary that the person using it have some experience in dealing with the strength of gear teeth. It is simple to apply, but the results are not so accurate as can be obtained by other methods.

The derivation of the parabola or Lewis method is illustrated diagrammatically in Fig. 1, where the tooth pressure P is resolved into two forces R and T meeting at point B. This is the top of the parabola, one leg of which is tangent at C to the tooth profile. The parabola thus constructed encloses a cantilever beam of uniform strength, which is tangent to the tooth outline at the weakest portion of the tooth—at points C and F. The problem is to determine the location of the line CF.

Determining the Weakest Section of Tooth by Calculation

In the improved method of determining the strength of gear teeth, as illustrated in Fig. 2, a gear tooth is drawn from four to ten times its actual size. The fillet on one side should be carefully drawn in, because the weakest section of the tooth generally lies in the vicinity of the fillet, and an inaccurately drawn fillet might change the calculated strength of the tooth considerably. If the gear tooth is to be cut with a generating cutter, the fillet should be "generated," whereas if the tooth is to be cut with a formed milling cutter, the fillet should be carefully drawn. If fairly accurate results are desired, a 10 to 1 scale is preferable. After the drawing of the tooth has been completed, a series of parallel lines e, e_1, e_2, and e_3 are drawn 0.100 inch apart and at right angles to the center line of the tooth. Then a line f is constructed. The pressure line P is drawn through the point of the tooth and tangent to the base circle, and the line f passes through the point of intersection of lines R and P.

Now, the weakest section of the tooth can be determined by measurements and by calculation. The procedure is to measure the length of line e from the vertical axis of the tooth to the tooth curve, or distance g. Then square this distance and divide it by distance h. This gives a factor. For example, g in this particular case equals 0.1015 inch and h equals 0.2 inch; then $0.1015^2 \div 0.2 = 0.0515$. Proceeding in this manner, starting well above what appears to be the weakest section and continuing until the values begin to increase again, the lowest value will indicate the weakest section of the tooth. The distance g_2 squared and divided by h_2 gives 0.05101, which lies between 0.0512 and 0.05107.

In order to prove that line e_2 indicates the weakest section of the tooth, measure and calculate on each side of line e_2, taking spaces 0.050 inch apart. In this way it can be determined very accurately just where the weakest section of the tooth really is. The value x obtained by squaring the base of the triangle at the weakest section and dividing by its height, as explained in the foregoing, gives the value x that is used in the Lewis formula, as illustrated in the diagram Fig. 1.

Factors Governing the Strength of Internal Gear Teeth

To show how the Lewis formula can be applied to internal gear teeth, it will be first necessary to explain briefly the difference between an internal and an external gear. An internal gear might be defined as an external gear turned inside out, so that the addendum of the teeth is within the pitch circle. This condition causes a different action of the teeth in that, for the same ratio of teeth, the length of the line of action is increased somewhat in an internal gear. Furthermore, modifications of the teeth are necessary on internal teeth when a small pressure angle and certain tooth

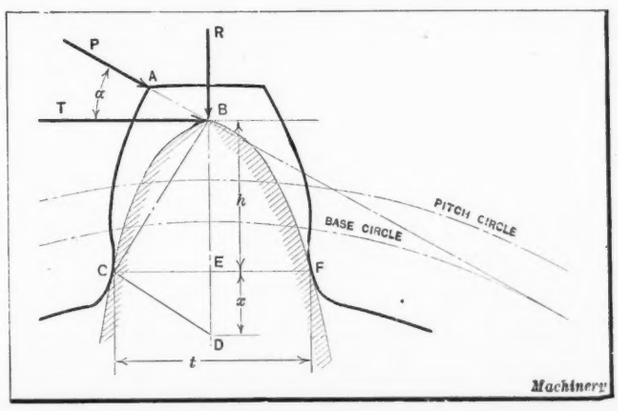


Fig. 1. Diagram used in the Derivation of the Lewis Formula

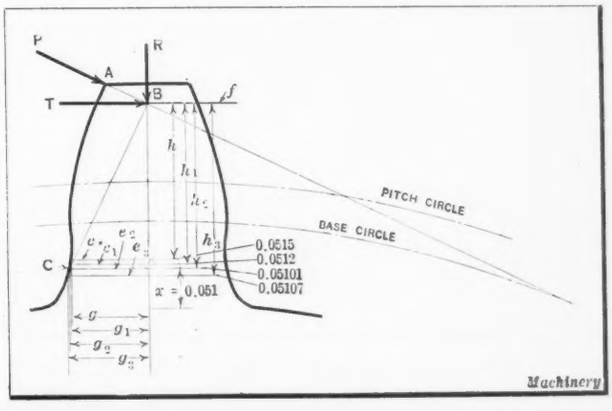


Fig. 2. Lay-out for finding the Weakest Section of a Gear Tooth

ratios are used. This will be seen in the lay-out at *A*, Fig. 3, which shows that if a pinion having 16 teeth of 8 diametral pitch is to run with an internal gear having 40 teeth, the pressure angle being 14½ degrees it is necessary that the teeth of the internal gear be entirely removed for the length of the cross-hatched portion *C* and that they be modified for the length indicated by the dark portion *D*. Increasing the number of teeth in the pinion and keeping all other factors the same, reduces the shaded and dark tooth portions as shown at *B*.

If the internal gear tooth is not modified, it will interfere with the flank of the pinion tooth, and the gears will not have the correct action. That part of the internal tooth which extends inside the base circle can be removed, as there can be no possible rolling action inside the circle from which the involute is generated. The gear tooth is obviously stronger than the pinion tooth, so that, in determining the strength of an internal gear tooth, it is always necessary to deal with the pinion.

Determining the Initial Point of Tooth Contact

In calculating the strength of an internal gear tooth, the initial point of contact of the pinion and gear teeth must first be determined. This is governed by several factors—the pressure angle, the tooth length, the ratio of the gear and pinion, the type of cutter used, and the relative number of teeth in the cutter used, if it is of the gear-shaper type. The first three points are made clear in diagram Fig. 4, in which are constructed the pitch, base, and root circles, as well as the inside circle of the gear and the outside circle of the pinion. There are 40 teeth of 8/10 diametral pitch on the gear, and 16 teeth on the pinion, the pressure angle being 20 degrees. If there is no under-cutting of the pinion tooth, which is practically the case with the conditions shown, that part of the internal tooth that extends inside the initial point of contact *E* will interfere with the flank of the pinion, and should be modified to give proper action. The initial point of contact *E* is that point at which a line drawn from the center of the pinion and at right angles to the line of action cuts the latter. This point also locates the base circle of the pinion. Now, regarding the cutter, if this is of the gear-shaper type and has a larger number of teeth than the pinion that is to run with the gear,

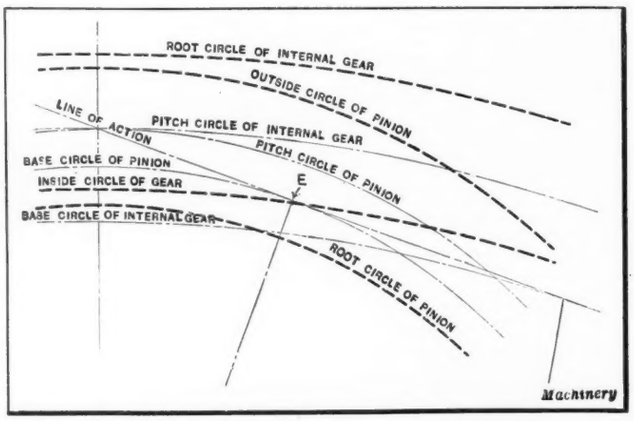


Fig. 4. Lay-out indicating the Manner in which Certain Factors control the Location of the Initial Point of Tooth Contact

it will in certain cases cut away more of the tooth than is actually required, and hence the initial point of contact will take place farther along the line of action. It is therefore necessary to take the number of teeth in both the cutter and the pinion into consideration, as they determine, in connection with the other factors mentioned, the location of the initial point of contact.

Application of the Lewis Formula to Internal Gear Teeth

To illustrate how the Lewis formula is applied to determine the strength of internal gear teeth, assume that it is necessary to find the strength of the internal gear represented at *A*, Fig. 3. Here, the initial point of contact *F* is advanced along the line of action from point *E* which corresponds to point *E* in Fig. 4. It will also be seen in Fig. 3 that the internal gear will not run with this pinion unless the dark and cross-hatched parts of the tooth are corrected and removed, respectively. The point of application of the load on the gear tooth is, of course, along the line of action at the point of contact.

Calculation will show that x is equal to 0.177 for the gear tooth, and to 0.042 for the pinion tooth. An increase in the number of teeth in the pinion, all other conditions remaining the same, affects the strength of the internal gear tooth. By increasing the number of teeth in the pinion to 24, and keeping all other factors as they were, as shown at *B*, factor x for the pinion is increased to 0.0515, and for the internal gear tooth it is reduced to 0.135. This results from the longer leverage or effective lengthening of the tooth. Obviously, the shorter the tooth, relative to the thickness at the base, the stronger it is; and by increasing the length of the tooth, keeping the base the same, the tooth becomes weaker.

Fig. 5 shows the effect of an increase in the pressure angle and the use of a stub tooth on the strength. At *A* is shown a 13-tooth pinion of 8/10 diametral pitch, 20-degree pressure angle, in mesh with a 40-tooth internal gear. The darkened portion indicates the amount to be removed from the gear tooth to insure proper action. The value of x for the gear is 0.129.

A gear and pinion having the same ratio of teeth, but of 8 diametral pitch and 14½-degree pressure angle, is shown at *B*. More trimming is necessary, thus reducing the effective length of the tooth, and although the pressure angle is less, the tooth is theoretically stronger, owing to the shortening of the working length, the value of x being 0.1480. It is evident that a shortening of

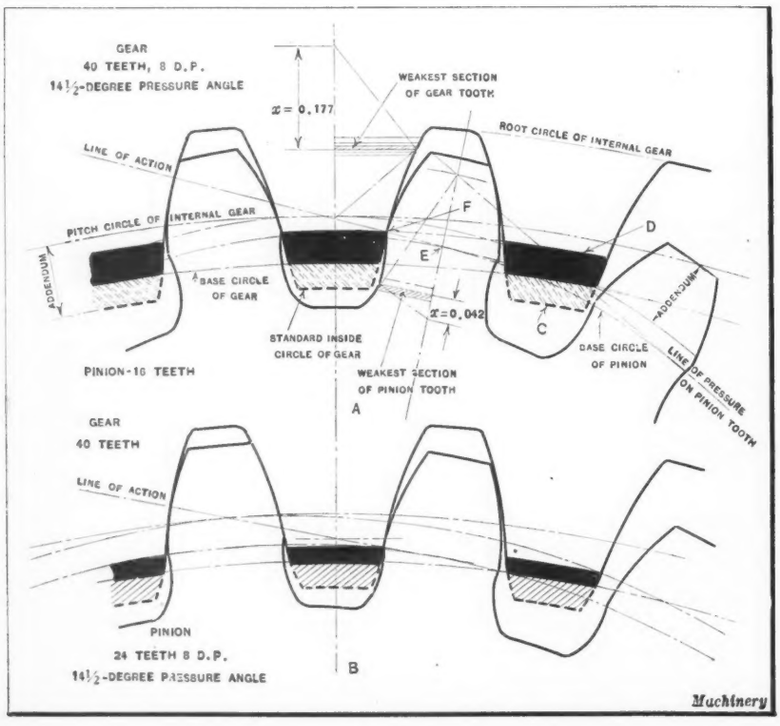


Fig. 3. Modifications Necessary on Internal Gear Teeth

the tooth affects the strength more than an increase in the pressure angle. Of course all the factors involved have not been discussed—only the main points regarding the effective strength have been explained.

One reason that the strength of internal gears does not receive more attention is that when an internal gear and pinion are made from the same material, the pinion is obviously always the weaker member, and the strength of the internal gear teeth is immaterial. But when an internal gear is made from one material and the pinion from another, it is necessary that the strength of both be found. In this connection, it might be stated that when an internal gear and pinion are to be made from the same material, the strengths of the pinion and internal gear teeth are sometimes balanced approximately. This is done by increasing the thickness of the pinion tooth at the pitch line, and increasing the width of the tooth space in the internal gear a proportional amount. This can only be done by a cut-and-try method, but it is comparatively simple in application.

A modification of the Lewis formula in which the value x as found by the method outlined in this article may be used, is as follows:

$$W = Sf \times \frac{2x}{3}$$

in which

W = applied load in pounds;

S = safe stress in pounds per square inch;

f = width of face in inches; and

x = factor determined as previously explained.

There is no necessity for including the circular pitch in the formula, as this is taken into consideration in determining the weakest section of the tooth. This formula gives exactly the same results as the Lewis formula.

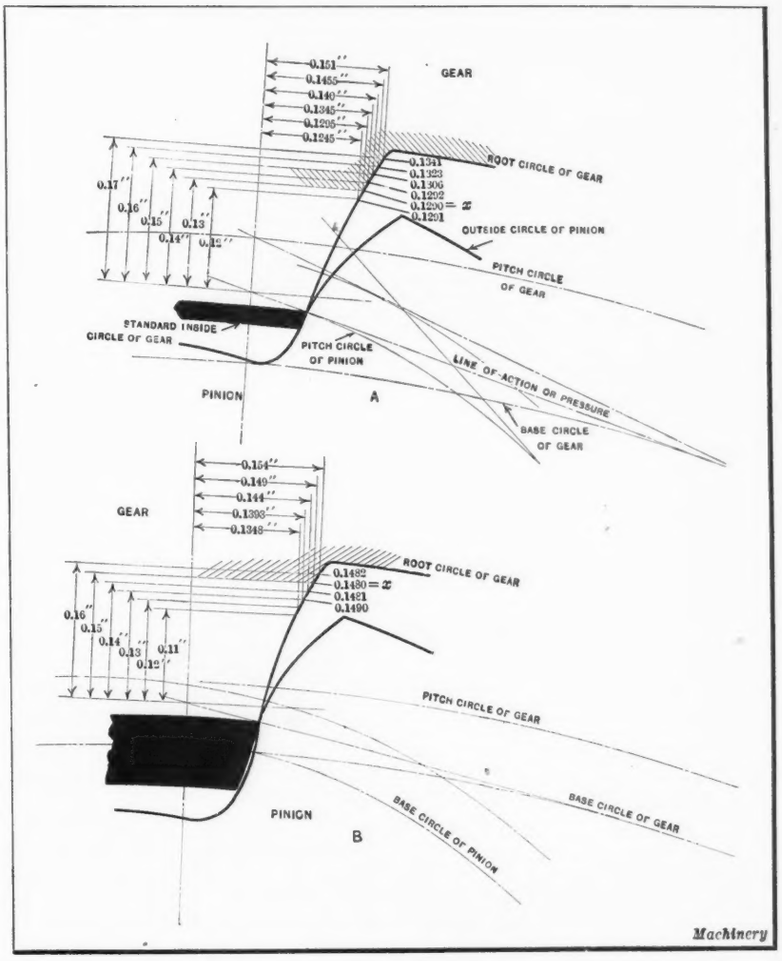


Fig. 5. An Application of the Method described

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FORGING AND COLD-DRAWING OF INVAR

Invar, an alloy steel very high in nickel, is difficult to work mechanically. Experiments have been conducted by the metallurgical division of the Bureau of Standards with a view to determining the conditions under which forging and cold-drawing of invar may be possible. It was found that very light reductions could be made at one heat, and that the forging temperature should not be allowed to drop below 1800 degrees F. during the first reduction. The experiments consisted of forging an ingot down to a ⅜-inch rod; a part of this rod was then cut off and machined to a ¼-inch diameter, and this part was then cold-drawn, with two intermediate annealings, to a wire approximately 1/16 inch in diameter.

EMPLOYMENT SERVICE OF NATIONAL ENGINEERING SOCIETIES

The employment bureau of the four national engineering societies—the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Institute of Electrical Engineers—is rendering a valuable service to the members of these societies as well as to the industrial world at large. The service of this employment bureau is unique in that it is given free of charge to both employer and employe, and hence can be rendered in a perfectly impartial manner, the best men obtainable being supplied to fill available positions. Many large corporations throughout the country are now using this employment service, and are obtaining through it not only engineers for technical posi- the applicants will be arranged for whe this is requested.

All the engineers whose records are listed in the employment bureau are members of one or more of the national engineering societies. When any concern applies to the bureau for a man of a certain type, the records of a number of men will be sent if desired, and a personal interview with the applicants will be arranged for, if this is requested. The applicants are carefully selected by the bureau according to the qualifications specified by the prospective employer. The bureau has on file not only the records of technically trained and experienced men, but also of specialists with engineering qualifications—production engineers, sales engineers, purchasing agents, traffic managers, chemists, etc. The bureau is under the charge of Walter D. Brown with headquarters at 29 W. 39th St., New York City.

The records of the bureau show an interesting trend toward improved business conditions. Up to the end of February, this year, the number of unemployed engineers on file increased every month, but beginning with March the number of engineers placed has exceeded the number that have applied for positions during each month.

* * *

It is reported that the Swedish Machine Tool Export Co., a sales organization representing a number of the leading Swedish machine tool firms, has obtained a contract for machine tools valued at over $300,000 to be delivered to a newly established locomotive works in Poland, partially supported by the Polish Government.

New Design of Centering Machine

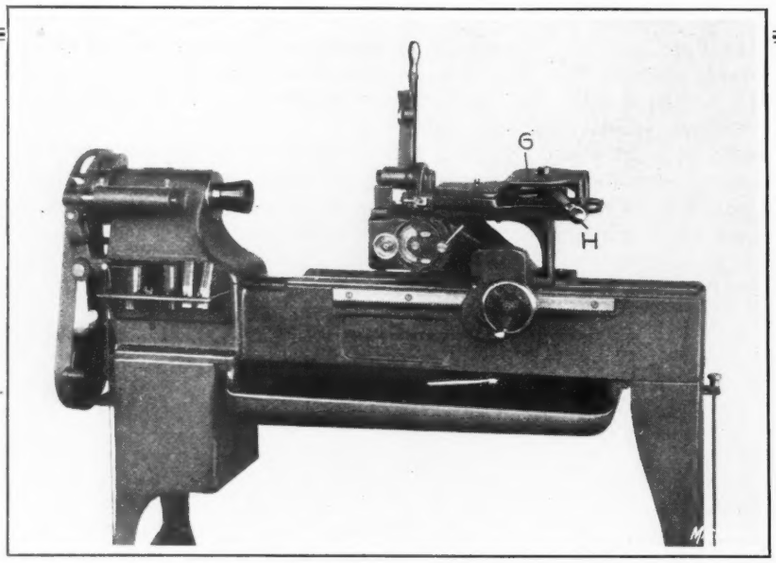


Fig. 1. Centering Machine with Simplified Chucking Method which permits the Centering of Ends of Various Cross-sections

Numerous parts produced from bar stock in turret lathes and automatic screw machines later undergo grinding, milling, or other operations in which it is desirable to have the work mounted on centers. A list of such parts would include reamers, taps, and a large variety of automobile parts and other pieces on which it may be necessary to mill an integral spur or bevel gear, a worm or a thread. The centering of parts produced in large quantities should be performed on a simple machine that operates quickly, so that the centering cost per part will be negligible. The Hanson-Whitney Machine Co., Hartford, Conn., has recently improved the centering machine of its manufacture which was described in August, 1921, MACHINERY, the new features including a greatly simplified chucking arrangement and a rack-and-pinion feed for the tool carriage. The ends of the work are centered by successive drilling and countersinking operations.

The Chucking Features

Centering is accomplished on this machine with the work rotating, one end being driven by the chuck, while the other end is supported by the rollers of a steadyrest close to the centering tools. The chuck on the original machine gripped the work by means of jaws that were opened and closed by a handle, and, although satisfactory, it was a rather complicated design. On the new machine the set of five hardened internally threaded parts seen on the tray of the headstock in Fig. 2 serve as chucks. One end of the work is inserted into the proper sized chuck, as shown in the cross-sectional view of a chuck at the top of Fig. 4. The chucks have a triple thread which insures that the work will be gripped at three points, one of which is directly opposite the other two.

The chuck has a capacity for work from ¼ to 3 3/16 inches in diameter. From Fig. 4 it will be noted that work of a variety of cross-sections can be held, but, of course, there must be a round cross-section at some point close to the ends to permit supporting by means of the steadyrest rollers. With a part having a hexagonal head, for instance, centering of the head end would be accomplished with the steadyrest rollers revolving on the shank of the part immediately beneath the head. Each chuck is held in the headstock spindle by means of a projecting pin on the shank which engages a slot that is clearly shown in Fig. 2, in the end of the spindle. A spring detent in the spindle hole also engages a groove in the chuck shank as a further precaution against the chuck becoming disassembled from the spindle while the machine is in operation.

Design of the Steadyrest

A close-up view of the steadyrest, which is integral with the front end of the tool carriage, is shown in Fig. 3. It will be seen that two rollers support the work underneath. These rollers are adjustable to suit the diameter of the work at the point where it rotates on the rollers. Adjustments are made by revolving the knurled handwheel *A* which is attached to a screw having a right-hand thread at one end and a left-hand thread at the other. Mounted on this screw are two nuts which are simultaneously brought toward each other or moved apart as the screw is revolved.

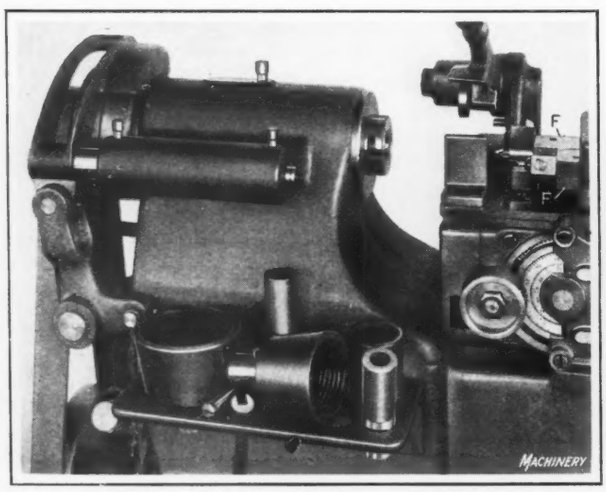


Fig. 2. View showing the Improved Headstock and Tray of Chucks

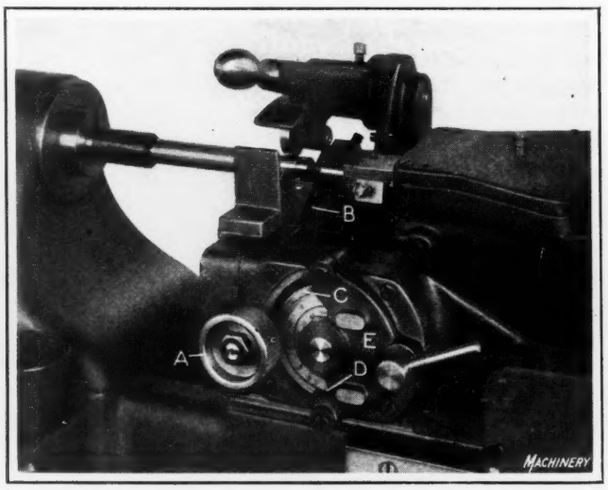


Fig. 3. View of the Steadyrest Rollers and their Adjusting Mechanism

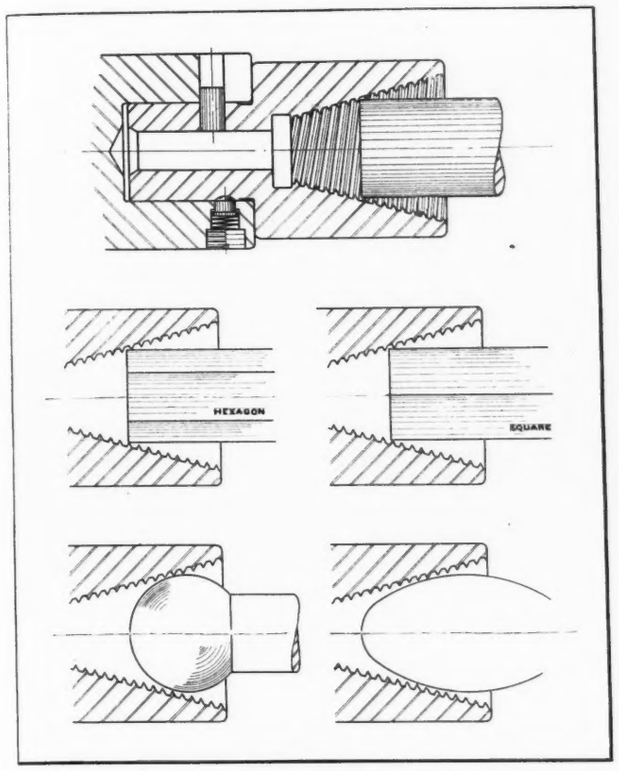


Fig. 4. A Few of the Typical Ends of Parts that can be chucked in the Machine shown in Fig. 1

Machined lugs on the nuts engage slots in the roller-holders *B*, and consequently the roller-holders are fed upward or downward at an angle when the handwheel is turned. The screw has pinion teeth cut on it near the front end which engage the teeth of gear *C*. This gear has two dials on the outside face, one of which is graduated in thirty-seconds of an inch, and the other in millimeters.

In setting the steadyrest rollers for work dimensioned in inches, handwheel *A* is revolved until the proper graduation of the dial on gear *C* is brought into line with edge *D* on clamp *E*. After a setting has been made, clamp *E* is tightened against the face of gear *C* by means of the binding handle. Handle *A* cannot be revolved until the binding handle is again loosened. The upper roller of the steadyrest is attached to a handle which is raised and lowered each time work is inserted. A coil spring in the bearing of this handle prevents it from dropping when raised.

Operation of the Centering Tools

The tool carriage is moved along the bed to suit the length of the work being centered, by revolving its handwheel. This actuates a pinion which engages with a rack on the front of the bed. The drill chuck and countersink are each held in holders which have shanks that are inserted in the ends of sliding bars *F*, Fig. 2. The drill chuck is mounted in the forward sliding bar and the countersink in the rear one. These sliding bars are mounted in bracket *G*, Fig. 1, which is rocked forward and backward to bring the drill and countersink successively into alignment with the work axis, when handle *H* is directly at right angles to the center line of the tool carriage. Pulling handle *H* ahead of this position causes the drill to be fed into the work, and pulling the handle to the rear causes the countersink to be advanced. Stops prevent bracket *G* from rocking when either tool is being advanced, and control the depth of drilling and countersinking. Long life of the countersink is obtained by grinding both ends for cutting, and the ends are ground eccentrically so that the tool cuts only on the bottom edge. This design tends to hold the work on the lower rollers of the steadyrest, and so not much pressure need be applied to the steadyrest lever.

Oil is supplied to the points of the drill and countersink by an ingenious arrangement. The pump and oil are contained in the compartment underneath the front end of the bed, the pump being driven by belt from a pulley mounted on the spindle outside the loose pulley. By this arrangement the pump is driven only with the spindle. Oil is pumped through a telescopic shaft in the bed which connects with a member on the tool carriage. The oil is forced through the arm upon which bracket *G* swivels and forward through sliding bars *F*, Fig. 2, and the tool-holders, being finally delivered to the tools. By means of an automatic arrangement oil is delivered to a tool only as it is being fed forward, and is immediately shut off as the other tool begins to advance. The starting and stopping of the machine is effected by a foot-treadle, which operates the belt-shifter. Thus the hands of the operator are entirely free for the removal and insertion of work and the operation of the tool-feeding handle. A piece of leather on the belt-shifter acts as a brake on the spindle as soon as the belt is thrown on the loose pulley. Both the spindle and loose pulley are provided with ball bearings. The standard spindle speed is 850 revolutions per minute.

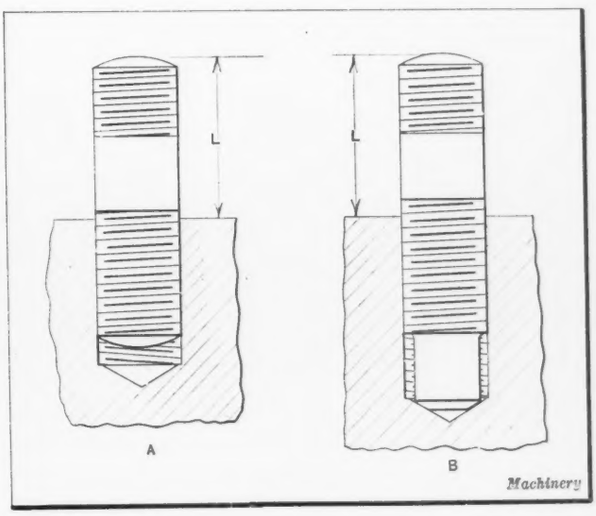
* * *

STUD BOLTS

By LEROY M. CURRY

Two designs of stud bolts are shown in the accompanying illustration. The bolt shown at *A* is the type in most general use, while that at *B* is an improved design. The improved style has the end turned down below the root diameter of the threads for a distance sufficient to allow for imperfect threads at the bottom of the hole. The idea is to enable the bolt to be locked or clamped in the hole, by bottoming the chamfered or rounded end of the bolt.

In view *B* it is obvious that length *L* depends only on the depth of the drilled hole and the length of the stud, both of which are easy to maintain as close as necessary. With the construction shown at *A*, there is always much trouble because of variation of the length *L*, and if the threads are not a good tight fit in the hole, the studs are quite likely to turn when the nut is being removed from the upper end of the stud. This is because the stud only tightens on about two imperfect threads either at the top or the bottom of the hole; whereas with the other form, the threads are jammed their entire length, even though the stud is not a tight fit in the tapped hole. On account of the initial strain placed on the threads by tightening the stud, it is advisable that the holes into which the studs are inserted be made a little more rather than less, than the nominal depth required, especially in castings.



(A) Common Style of Stud Bolt; (B) Bolt with End turned down

Babbitt Metal

By L. D. ALLEN, General Manager, L. D. Allen Metal Works, Chicago, Ill.

WHEN we consider that from 20 to 30 per cent of the power developed for the operation of machinery is lost in bearing friction, it is surprising to note how little attention is paid to this loss. The explanation is that only by the installation of carefully constructed testing apparatus can the real cause be discovered. It is the pull or drag in each bearing, multiplied by the number of bearings throughout a plant, that accounts for the great losses in power and the large expense in repair bills, the latter being due to the wearing or burning out of bearings, unnecessary oil consumption, wear on driving gears and belting, etc.

Very few people realize the significance of the fact that 400 pounds or more of each ton of fuel burned under the boilers is consumed by the friction load. Power that is wasted through friction is converted into heat. This heat, to avoid fusion of the bearing liner, must be radiated as fast as it is produced so that the temperature of the bearing surface will be kept below the danger point. For this reason the anti-frictional and heat-conducting properties of a bearing liner are important, although not so important as the load-carrying and cohesive strength of the liner. The consistency and heat-conducting properties of the lubricant, as well as the method of lubrication, are also important factors. The reason that the anti-frictional properties of a bearing metal are not quite so important as its load-carrying properties is that the oil film is supposed to prevent metallic contact between the journal and the bearing surface. The cause of bearing failure is many times due to the journal being forced into full load and speed before the oil film has had an opportunity to warm up and spread sufficiently to cover the entire rubbing surface.

Babbitt metals should never be bought on a price basis, but solely with regard to their adaptability for the bearings for which they are to be used. The more dense and compact the structure of the bearing liner, the less will it give or compress under the journal pressure. Vibration usually occurs when a metal gives and creates an excessive space between the journal and the bearing surface. For this reason all bearing metals must be carefully alloyed under experienced supervision, because a slight variation in ingredients and in the manner of combining them will change the metal from a dense, homogeneous alloy to a coarse-grained mechanical mixture of doubtful quality.

Apart from the retarding influence of an unsuitable lubricant, friction is caused by the unevenness of the surfaces in moving contact. There are no absolutely smooth surfaces. They may seem smooth to the touch, but a strong magnifying glass will reveal minute projections and roughnesses, which in rubbing contact produce friction and heat. In the manufacture of bearing metals, it is important, therefore, that only such constituent metals be used as will produce a smooth, mirror-like bearing surface. Lead possesses the best anti-frictional properties, but lead alone is too soft to carry the load, and therefore must be strengthened by the addition of antimony to give greater hardness, and tin and copper to give both hardness and toughness. In a bearing metal, tin also serves as a solder to unite or bind together the ingredients of which the alloy is composed.

Load on Bearings

Carefully conducted tests in research laboratories have proved that the maximum load per square inch on any type of bearing should not exceed 2500 pounds, and that three-fourths of the machinery in operation should carry a bearing load not exceeding 1500 pounds per square inch. If the bearings are of the proper dimensions with respect to the length, diameter, and thickness of the liner, and positive lubrication is assured, it has been found that a babbitt metal, triple alloyed, semi-tin or lead-based, is the most durable and economical metal for bearing loads up to 1800 pounds per square inch. A babbitt metal of this nature, properly produced, will show a compressive strength, when a block or cube, one inch square is tested, of from 16,000 to 20,000 pounds, but this does not mean that it will stand more than approximately 1800 pounds per square inch of surface of a liner ⅛ or ¼ inch thick. The thinner the liner under heavy load and stress, the higher the tin and copper content required in the alloy.

For extremely severe bearing conditions, what is known as "genuine babbitt" is sometimes used because of its toughness and ability to resist bending stresses. Genuine babbitt is composed of from 80 to 90 per cent of tin. A moment's reflection will suggest, however, that bearing liners are very rarely subjected to bending stresses. In 99 per cent of the cases, a metal low in tin, that will withstand the bearing pressure and that will not heat when the surface is subjected to journal friction, is the best metal to use. The author, who for a long period of years has specialized on bearing metals, has in many cases replaced tin-base genuine babbitts with alloys, containing from one-third to one-half less tin, and which are toughened and hardened through the methods by which they are produced. These alloys can be made at a proportionately lower cost to the user and are of greater service value, because of their better anti-frictional properties. They are of sufficient strength to carry the load, but because they contain a higher percentage of lead, they heat less under given speeds and pressures.

The following experience may be mentioned as an example. The writer was asked to visit the East St. Louis plant of the American Car & Foundry Co., where trouble had been experienced with bearings in the overhead drives. The bearings that gave the most trouble were made of genuine babbitt containing about 88 per cent tin. These bearings gave trouble by melting or fusing; the metal, being high in tin, heated more rapidly under journal friction than a metal containing a large percentage of lead. Furthermore, the overhead bearings were somewhat neglected as regards lubrication. A hard lead-based babbitt with a compression test of about 1800 pounds per square inch was substituted, and the trouble disappeared.

Considerations in Buying Babbitt Metal

Babbitt metals should never be bought on a price basis, but solely with regard to their adaptability for the bearings for which they are to be used. The more dense and compact the structure of the bearing liner, the less will it give or

compress under the journal pressure. Vibration usually occurs when a metal gives and creates an excessive space between the journal and the bearing surface. For this reason all bearing metals must be carefully alloyed under experienced supervision, because a slight variation in ingredients and in the manner of combining them will change the metal from a dense, compact, homogeneous alloy to a coarse-grained mechanical mixture of doubtful quality.

It is erroneous to recommend a single lead-based brand of babbitt as suitable for all conditions. Bearing conditions may be classified under three headings—general-purpose conditions, that is, average speed and average to heavy loads; extra heavy conditions, that is, fairly high speed and heavy load; and extreme service conditions, that is, extreme speeds and loads, especially when the bearings are also subjected to vibration, intermittent loads, pounding and shocks.

Composition of Bearing Metals

The metals used in the manufacture of various babbitts are two or more of the following: Tin, lead, copper, antimony, and bismuth.

Tin toughens the alloy, lowers the melting point, and assists in producing a strong, homogeneous mixture. It is a "dry" metal, that is, it is somewhat lacking in anti-frictional properties. Under heavy friction it heats quickly and fuses. When heated, it melts at about 450 degrees F.; its specific gravity is 7.35 and its comparative hardness is 4.5. The grades generally used in the manufacture of babbitt metals are known as Straits tin, Chinese tin, and Bolivian tin, depending on the standard of purity required.

Lead imparts softness and reduces the tendency to heat in a bearing by reducing friction; it has greater friction-reducing qualities than any other metal, resembling graphite in this respect. It melts at about 620 degrees F. Its specific gravity is 11.38, and its comparative hardness 1.5.

Copper hardens and toughens a bearing alloy and raises the melting point. It increases the friction slightly. Copper melts at a temperature of 1943 degrees F. It has a specific gravity of 8.85, and a comparative hardness of 2.5. Very little copper is used in babbitt metal, only from 0.25 to 0.5 per cent being used in a lead-based babbitt. There are some high-tin mixtures that contain as much as 10 per cent copper such as hard genuine babbitt, which is composed of 80 per cent of tin, 10 per cent of antimony, and 10 per cent of copper. The author does not believe that copper is a desirable constituent in a lead-based babbitt. It hardens the babbitt somewhat, but it reduces the anti-frictional properties, and imparts less compactness or density to the structure or body of the alloy.

Antimony is a hard, brittle metal of crystalline structure. It hardens an alloy and raises the melting point. It reduces friction, thereby reducing the heating of the bearing. It melts at about 1169 degrees F. It has a specific gravity of 6.76, and a comparative hardness of 3.5. The crystalline grain of a fracture is due to antimony. It is imperative that the antimony in a bearing alloy be completely reduced and evenly distributed throughout the mass; otherwise there will be hard, segregated spots on the surface of the liner, developing frictional heat and cutting or scoring the journal.

Bismuth reduces friction and prevents shrinkage, as it expands on cooling. It lowers the melting point of an alloy, as it melts at a temperature of 507 degrees F. Its specific gravity is 9.82, and its comparative hardness 2.3. As bismuth usually costs more than $2 a pound, it is not used to a large extent in babbitt alloys.

Aluminum is rarely used in babbitt metal except as a deoxidizer. It melts at a temperature of about 1160 degrees F. Its specific gravity is 2.6, and its comparative hardness 2.2. It imparts some toughness by closing the grain, and acts as a flux; but it slightly increases the friction, thus offsetting its toughening properties, and making it of no practical value in a bearing metal.

Certain combinations of tin, copper, and antimony shrink on cooling. Tin and lead alone shrink slightly, and antimony remains about constant. Any two metals mixed together in the form of an alloy produce a metal which has a lower melting point than that of the original metal having the higher melting point, and in some cases lower than that of the metal with the lower melting point.

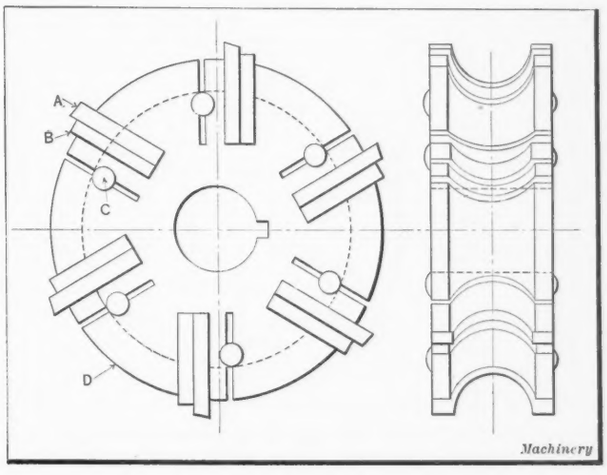
* * *

INEXPENSIVE FORMED MILLING CUTTER

By GEORGE C. HANNEMAN

The high initial cost of formed milling cutters often precludes their use on work for which they are otherwise well adapted. The formed cutter illustrated is, however, comparatively inexpensive to make. It can therefore be used in many instances where production requirements do not justify making a formed cutter of the usual type. The cutter shown has removable blades, and is made by a method that eliminates the expensive backing-off process. The body of the cutter is milled exactly the same as for an ordinary inserted-blade cutter except that the blade slots are made about twice as wide as the blades are thick. The remainder of the space in each slot is filled by a soft steel spacer block such as shown at *B*.

In making the cutter, each spacing block is placed in front of its respective blade and clamped in place by a taper pin *C*. The cutter blades are then turned to shape without

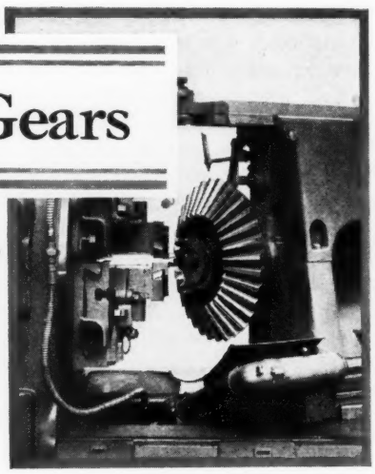


Inserted-blade Type of Formed Milling Cutter

backing off. A cut is also taken on the sides of the blades to obtain true surfaces from which to reset or locate the blades after they have been hardened. The blade shown at *A* is in the position occupied when its profile is being turned, while the other blades are shown in their proper working positions. The slots and their corresponding blades are numbered before the blades are removed for hardening.

After being hardened, the blades are properly located in the body *D* by mounting the latter member on an arbor in a lathe, using an indicator to assist in bringing the trued-up sides of the blades into alignment. It will be noted from the illustration that the cutter clearance is obtained by changing the position of the spacing blocks so as to lie behind the cutting blades instead of in front of them. For very accurate work it is necessary to allow for the slight change in depth of cut which results from moving the blades forward. The widths of the turned surfaces will not be affected by this change in the cutter position, but the depth of the cutter profile must be made slightly less, as in the case of screw machine tools of the circular type. For special parts that are required in limited quantities, the use of this type of formed cutter has been found very economical. The body *D* of the cutter can, of course, be used for blades of different shapes.

Cutting Large Bevel Gears



Methods of Stocking out and Finishing Bevel Gears on Single- and Two-tool Planers of the Form-copying or Templet Types

By FRANKLIN D. JONES

VERY large bevel gears, and many of medium size, are cut by using gear planers of the templet or form-copying type. Such machines are also used for cutting the larger sizes of spur gears, as explained in a previous article, but their application to very large bevel gears is universal. More distinct types of machines have been designed for cutting spur gears of various sizes than for cutting bevel gears, since the former present a simpler gear-cutting problem. For instance, spur gears may be cut readily with formed cutters, and a great many are produced by this simple method; but as the tooth of a bevel gear has the same cross-sectional shape on a diminishing scale toward the apex of the pitch cone, it cannot be given the correct shape with a formed cutter, although this method has been used to a limited extent for bevel gears. The templet principle, however, provides a relatively simple method of cutting bevel gears of medium and large sizes, especially in gear shops or wherever a variety of pitches or sizes is encountered; this accounts for the general use of the templet or form-copying type of gear planer for the class of work mentioned.

Cutting Bevel Gears on Planers of the Single-tool Form-copying Type

Bevel gear planers of the form-copying type commonly operate with a single tool, although a two-tool design has been developed, which will be described later. The single-tool Gleason planer of 24-inch size is shown in Fig. 1. When this planer is at work, the tool-slide is given a reciprocating motion by a crank adjusted for a stroke equal to the face width of the gear being cut, plus about ¾ inch over-travel, or possibly 1 inch on larger machines. The arm carrying the tool-slide is pivoted so it can swing about a horizontal axis. The entire tool-head (with its tool-slide, crank drive, and pivoted arm) is mounted on a turret or baseplate supported by the main bed.

This turret swings about a vertical axis to feed the tool inward, and at the same time the tool-slide arm swings about its horizontal axis, provided the supporting roller *R* is resting on one of the curved forms or templets *B* or *C*, which are used when taking finishing cuts. The inward feeding movement and the backward motion to withdraw the tool for indexing are obtained from a cam acting through an adjustable lever for varying the angle through which the turret swings. This angular movement is regulated according to the depth of the gear teeth, and is equal to the angle subtended by the whole depth of the tooth, plus 1½ degrees for clearance. The turret is set to suit the pitch cone angle of the gear being cut.

When cutting teeth from the solid, the tooth spaces are first roughed out, as described later, and then the teeth are finished first on one side all around the gear and then on the opposite side. The holder to which the forms are

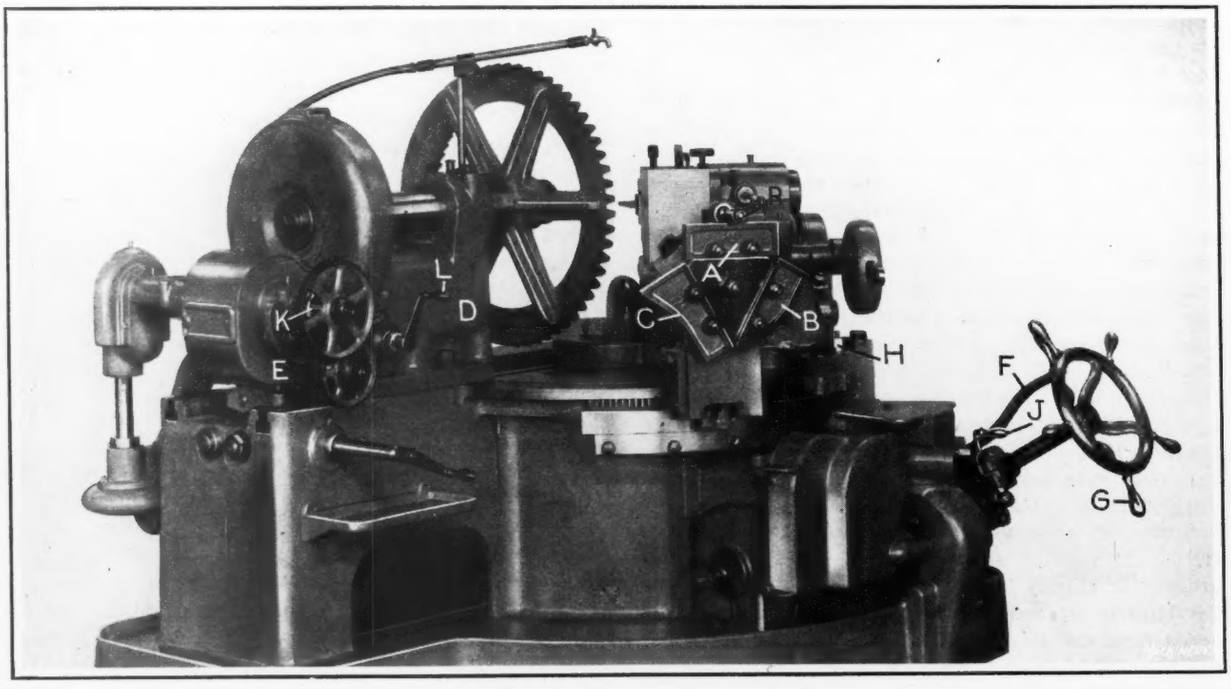


Fig. 1. Bevel Gear Planer of the Single-tool Form-copying Type

attached can be turned about a horizontal axis for locating the different forms in the working position. The indexing movement of the gear being cut is controlled automatically through change-gears located at *E*, which are selected by referring to an index table furnished with the machine. The planer illustrated in Fig. 1 will cut miter gears up to 24 inches pitch diameter, and bevel gears of a 2 to 1 ratio up to 28 inches pitch diameter. Machines of the form-copying type are made for cutting gears up to the largest sizes ordinarily encountered in commercial work, and such machines have the advantage of using tools of a simple inexpensive form.

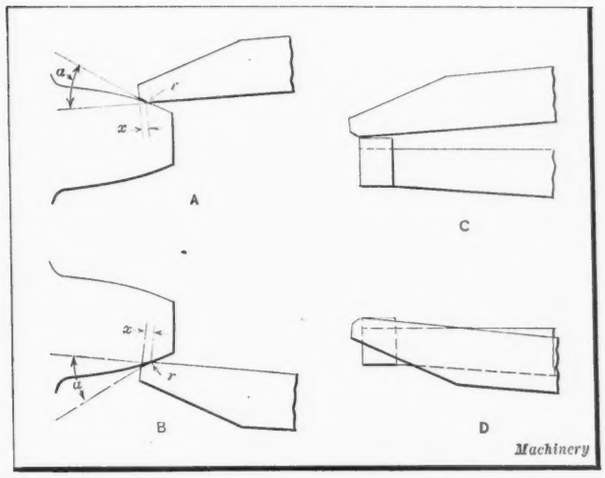


Fig. 2. Tools used for finishing Upper and Lower Sides of Teeth

When a bevel gear is cut from the solid (instead of planing teeth which have been roughly cast to shape, as is customary for very large gears) there are several methods of roughing or stocking out the teeth. When roughing steel or cast-iron gears up to about 2 diametral pitch, it is well to use a single V-shaped tool, as indicated by the diagram *A*, Fig. 3. While this tool may have plain cutting edges, the stepped or corrugated form indicated is preferable, as it breaks up the chips. The size of the roughing tool depends upon the width of the tooth space at the small end. The tool should be wide enough to leave about 1/32 inch of stock on each side of the teeth at the small end, and the length of the cutting end must be at least equal to the full depth of the teeth at the large end.

Sometimes when cutting "flat gears" (gears having a large pitch cone angle) of, say, 2 diametral pitch, especially if the section is light and the gear blank tends to spring, it might be necessary first to cut parallel slots in the center of each tooth space, as indicated by diagram *B*, and then follow with a V-shaped roughing tool. Gears coarser than 2 diametral pitch and with pitch cone angles of less than 45 degrees may be roughed out by using a combination slotting and V-tool, as indicated by diagram *C*. The combination slotting and V-tool arrangement is not readily applicable to the 24-inch gear planer, so it finds use only on the larger sizes. The slotting tool is always set to cut slightly deeper than the V-tool, so that the latter never cuts on the point. When cutting "flat gears," or those that have large pitch cone angles (above 45 degrees) there is sometimes a tendency for the work to spring in toward the tool and stall the machine when a heavy cut is being taken, which makes it necessary to relieve the cutting action by not setting the V-tool in to the full depth.

Another combination tool that is sometimes used is illustrated by diagram *D*. This is a narrow slotting tool extending to the full depth, followed by a wider slotting tool which goes in as far as the pitch line. When the work is such that combination tools cannot be used, and the pitch of the teeth is too large to permit roughing from the solid with a V-shaped tool, it is necessary to cut plain slots first and then follow with a V-shaped tool.

Diagrams *A* and *B*, Fig. 2, show the type of tool used for finishing the upper and lower sides of the teeth, respectively. The end of the finishing tool must be small enough to pass through the space at the small end without touching the tooth on the opposite side. The tools are rounded at r just enough to leave a smooth cut. The distance x and the angle a (which is about 35 degrees) should be the same for both finishing tools. The toolpost is so arranged as to allow the tool to swing away from the work during the return stroke, the same as on an ordinary planer. The tool is always returned to the cutting position by means of a stop, which should be properly adjusted before using the machine.

Setting the Tools

The tool-holders are so constructed that the tools may be adjusted for height by means of a wedge, and for lengthwise position by means of a stop-nut. A gage placed on the tool-slide arm shows when the tools are properly set. Diagrams *C* and *D*, Fig. 2, show the ends of upper and lower finishing tools set in correct relation with the end of this gage. In the first place, the roughing tool is inserted

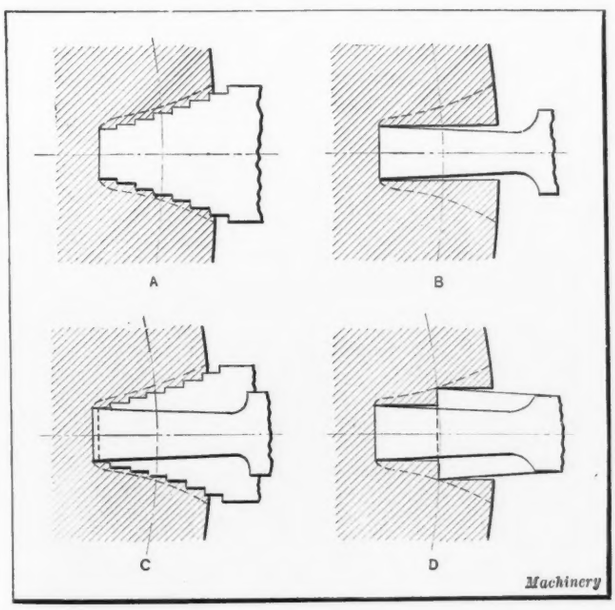


Fig. 3. Different Forms of Tools used for Roughing or Stocking Cuts

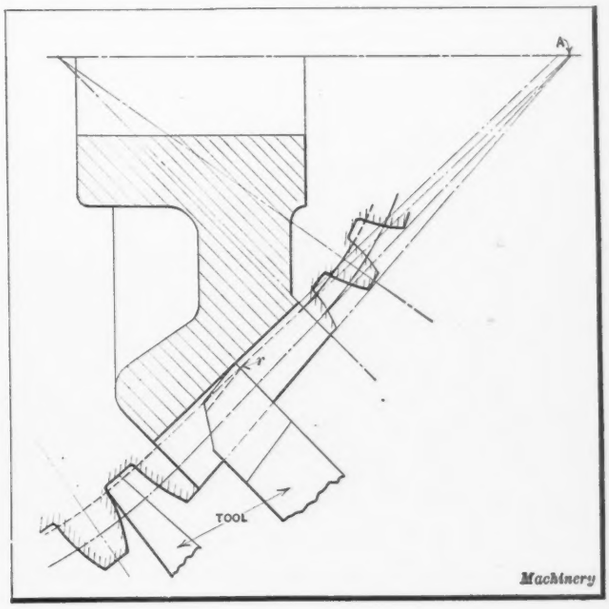


Fig. 4. Diagram showing how Clearance Space is formed by Planing Tool

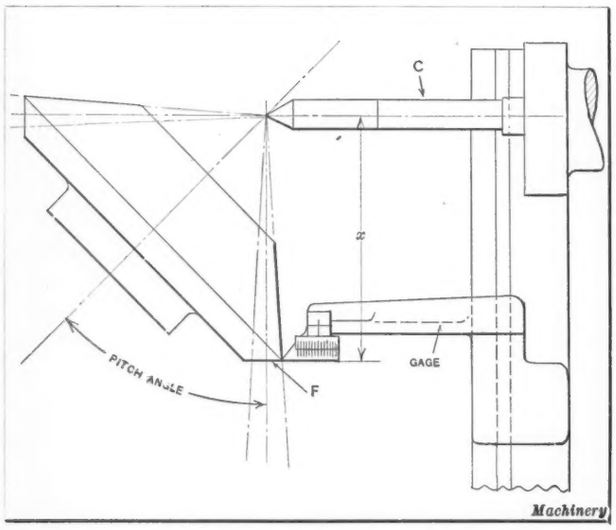


Fig. 5. Cone Distance Gage used for locating Gear Blank in Correct Position axially

in the toolpost, and the end is set even with the end of the gage. The tool is also adjusted for height until it is central with the end of the gage. The roughing tool is next replaced by the lower-side finishing tool, which is adjusted so that the cutting point r coincides with the outer corner of the gage, thus locating the tool vertically and lengthwise. The tool for the upper side is next set in the same way and is left in the machine for further adjustments.

When a pair of planed gears is in mesh, it will be seen that the clearance between the end of one tooth and the bottom of the corresponding tooth space is the same at both the large and small ends; consequently, the clearance at the small end is larger in proportion to the size of the tooth at this end, and it might be inferred from this that the gears are not properly in mesh. The clearance should, however, be the same at both ends, because when the tools are set as illustrated by diagrams C and D, part of the tool projects beyond the cutting point an amount represented by dimension x (see diagrams A and B). When the tool is set properly, the cutting point r travels along a line coinciding with the apex A of the pitch cone, as indicated by the diagram Fig. 4. This cutting point r will always travel toward A, or the center of the machine, as the tool feeds in across the surface of the tooth. As the clearance space is formed by that part of the tool projecting beyond the cutting point, the width of the clearance space at the large end of the tooth is the same as at the small end.

Angular Position of Turret

The turret which supports the tool-slide is set to the pitch cone angle by means of graduations on its base in conjunction with a fixed pointer. When this adjustment is made, an auxiliary centering form is attached to the form-holder in place of form C, Fig. 1, for the lower side. This centering form has a V-shaped notch, which engages roller R. The roller must be in contact with both sides of the V-slot in the centering form when the turret has been adjusted to the required pitch cone angle.

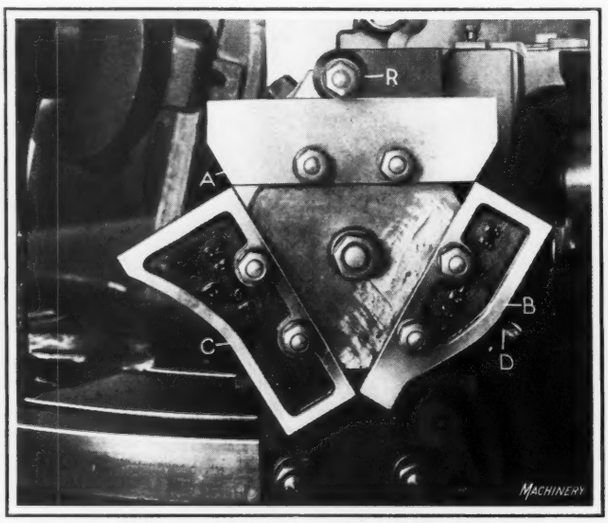


Fig. 6. Detail View of Forms on Gear Planer which control Movement as Tool feeds inward

Setting Gear Blank in Cutting Position

After the turret has been set with reference to the pitch angle, the head D carrying the work-spindle is adjusted along the bed to locate the gear blank in the proper cutting position. The gear blank will be in the right position when the apex of the pitch cone coincides with the center of the machine, or with the point of intersection between the vertical axis about which the turret swivels and the horizontal axis about which the tool-slide swivels. The cone distance gage, shown in Fig. 5, is used in making this adjustment. The vernier on the gage is first set to conform to the pitch depth or addendum of the gear to be cut. The gage is then placed on the tool-slide arm. The head carrying the work-spindle is next moved along the bed until the pointer of the gage stands at zero when the extreme outside edge of the gear blank is in contact with the vernier, as shown by the illustration. The gear blank is then in the correct cutting position.

When locating a pinion having a pitch cone angle of, say, 15 degrees or less, it is preferable to set the blank by measuring the cone distance x instead of using the cone distance gage. The cone distance or pitch cone radius can be determined by dividing half the pitch diameter by the sine of the pitch cone angle. This calculated dimension should correspond with distance x from the point of center-pin C to face F of the gear blank. The center-pin should be pushed all the way into its socket to locate the point at the center of the machine. A scale that is graduated in hundredths should preferably be used for checking this dimension.

Adjustment for Depth of Cut

A line representing the full depth of the teeth at the large end, is scratched on the back angle or face of the gear blank, and is used in setting the tools. This may be done accurately when turning the gear blank. On the 24-inch machine the tools are set by first disconnecting the feed clutch and engaging the hand feed clutch by means of lever F, Fig. 1. Then the feed-cam is turned by handwheel G until the cam lever has moved to the limit of its travel toward the left. The tool-slide is then shifted along the arm by hand, until the tool just clears the angular surface at the large ends of the teeth. Next a nut at H is turned until the turret has swung in far enough to bring the end of the upper tool (which was left in position) opposite the middle of the full-depth line scratched on the gear. The roughing

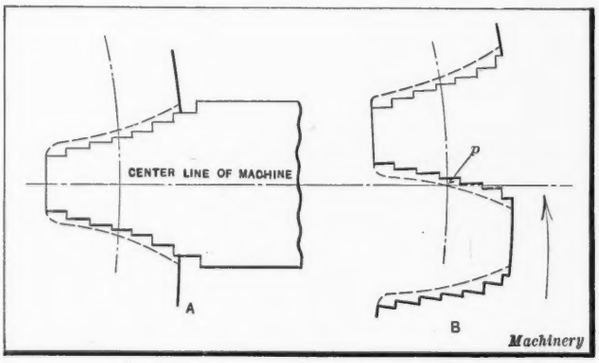


Fig. 7. (A) Position when roughing (B) Position when finishing

tool is then inserted and adjusted until it also reaches this line.

Provision is made for setting the toolposts at different angles in order to change the angular position of the tools relative to the gear. This adjustment, however, is not required for cutting involute teeth, and is only used for pinions having cycloidal teeth, the object being to provide clearance for the tool at the pitch line when cutting the flanks.

Taking Stocking Cuts

The index mechanism must be properly geared and adjusted, and the stroke, as well as the cutting position of the tool, must be so regulated that the tool has an over-travel of, say, $\frac{5}{8}$ inch at the large ends and $\frac{1}{8}$ inch at the small ends of the teeth. The rate of feed and number of strokes per minute must also be varied to suit the gear to be cut, which is done by using different combinations of speed and feed gears. The machine is now ready for the stocking cuts.

After determining the type of stocking tool to use, the first tooth space is roughed out. As the tool feeds straight in or radially, a straight edge is used instead of a curved form, and this is shown in the operating position in Figs. 1 and 6. When a tool is approaching the bottom of the first tooth space, care should be taken to see that it does not cut below the full-depth circle. When a slight change in depth is necessary, this is made by changing the travel of the turret. Crank *J*, Fig. 1, is used for making this adjustment.

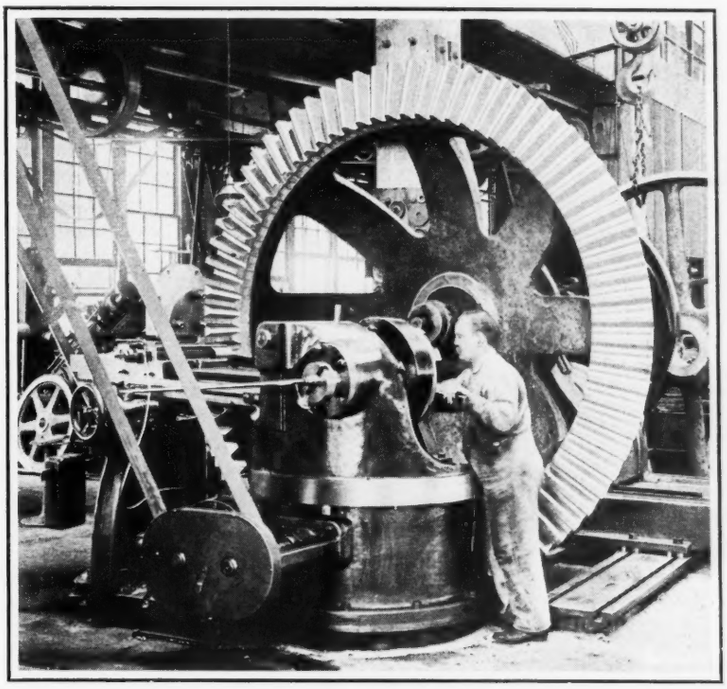


Fig. 8. Planing Cast-steel Bevel Gear having a Circular Pitch of 5 Inches

Taking Finishing Cuts

The forms that control the path followed by the tools when taking finishing cuts are selected according to the pitch cone angle, by referring to a chart accompanying the machine. The roughing tool is replaced by the upper-side finishing tool, and the form *B* (see Fig. 6) for the upper sides of the teeth is swung around to the operating position. A latch controlled by handle *D* engages a slot and locates the form-carrying plate. The plate should be tightened after the form to be used is in position.

When the gear is being stocked out, the roughing tool is in a central position relative to the center line of the machine or to a horizontal plane coinciding with the axis of the gear (see diagram *A*, Fig. 7). Before taking the finishing cuts, the gear must be rotated until pitch point *p* (diagram *B*) coincides with the center line of the machine. In order to change the position of the gear, a clutch at *K* (Fig. 1) connecting with the indexing gear train, is disengaged and crank *L* on the indexing worm shaft is used to turn one section of the clutch relative to the other section. If two cuts are to be taken for finishing each side (the second being a light finishing cut) crank *L* is turned to the right (assuming the upper sides of the teeth are to be planed)

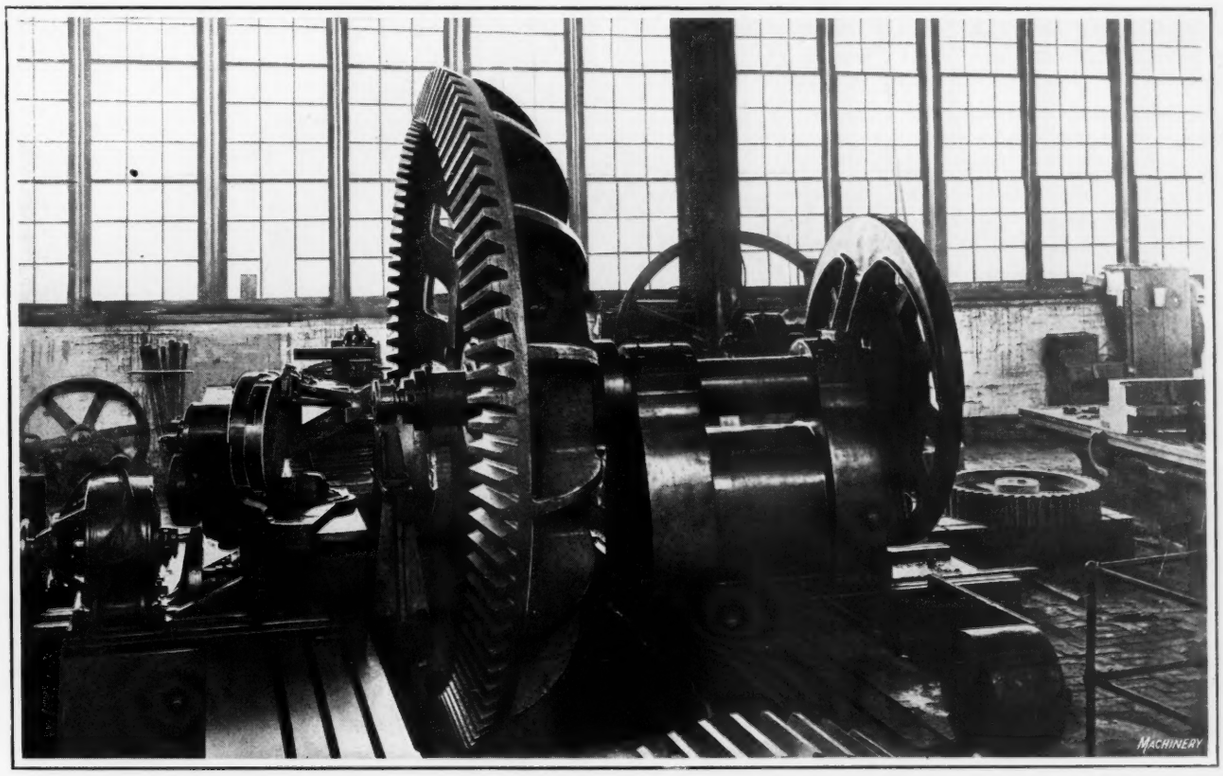


Fig. 9. Another Example of Large Bevel Gear Planing. In this Case a Pit is provided to permit swinging Gears of Large Radius

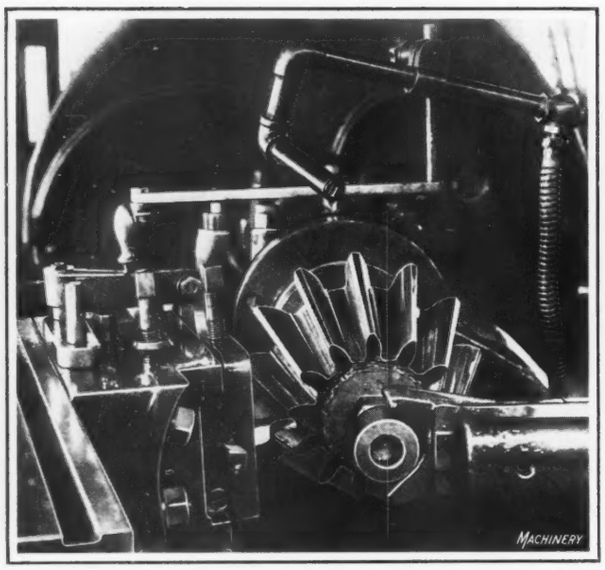


Fig. 10. Planing a Pinion having Teeth of Special Width

until graduation No. 1 on clutch *K* is one notch to the left of the zero line on the other half of the clutch. The pitch point *p* is now in the position indicated by diagram *B*, Fig. 7. After tightening the clutch lock-nut and engaging the feed clutch, a cut is taken over the upper sides of all the teeth. Then when the turret and tools are at the limit of their outer movement, the feed clutch is disengaged and graduation No. 1 on the index clutch is set opposite the zero position; finishing cuts are then taken on the upper sides of the teeth.

Before finishing the bottom sides of the teeth, it is necessary, of course, to replace the upper-cutting tool with the one used for under-cutting, and also place the form *C* (Fig. 6) for the lower sides in the working position under the roller. The gear must now be shifted, so that the pitch point on the side opposite *p* (diagram *B*, Fig. 7) coincides with the center line of the machine. The clutch *K* (Fig. 1) is again disengaged, and the two parts are shifted in the opposite direction or until graduation No. 3 is one notch to the right of the zero position. Cuts taken with the clutch in this position will leave the teeth somewhat wide.

When the final finishing cuts are taken, with graduation No. 3 in the zero position, the teeth should be about the right size, although as soon as the first tooth has been planed, its width should be tested either by using a solid gage of the right diametral pitch or an adjustable vernier gage. If a slight adjustment is necessary, this can be made by shifting a clutch on a worm-shaft which has a large number of teeth, in order to provide a finer adjustment than could be obtained with the clutch at *K*. The amount of stock that the tool will remove from the tooth when this clutch is shifted one notch depends upon the size of the gear, increasing as the diameter of the gear increases.

Examples of Bevel Gear Planing

An example of fairly large bevel gear planing from the plant of the Earle Gear & Machine Co., Philadelphia, Pa., is shown in Fig. 8. This is a cast-steel gear having a circular pitch of 5 inches, and a face width of 14 inches. The machine used is a single-tool form-copying type. In roughing out these teeth, a square-nosed or end-cutting tool was first used to remove stock from the center of each tooth space. Two roughing cuts with a round-nosed tool were then taken, and finally a finishing cut. Another example of large bevel gear planing is shown in Fig. 9, which is a gear-cutting job from the plant of R. D. Nuttall Co., Pittsburg, Pa. This gear planer is provided with a pit to permit swinging gears of large radius.

The detail view, Fig. 10, shows the cutting of a cast-steel pinion at the Philadelphia Gear Works. This pinion has thirteen teeth of 2½ inches circular pitch, but the teeth were made much narrower than standard, so that it was necessary to remove considerable stock. This was done by first taking a cut through the center of each space with a square-nosed tool. The bulk of the metal at the sides was then removed by again using the square-nosed tool set at an angle first for one side and then for the other. Finally the teeth were finished by using the general style of tool previously referred to for finishing cuts.

Two-tool Bevel Gear Planer of the Form-copying Type

While bevel gear planers of the templet type ordinarily have a single tool, the Gleason planer illustrated in Figs. 11 and 12 has two tools in operation at the same time, the machine being similar in this respect to the well-known generating type made by this company. This machine saves from 45 to 50 per cent of the cutting time, as compared with a single-tool planer. When taking roughing cuts, one tool is operating in one tooth space while the other tool works in the space following. When taking finishing cuts, both tools operate on opposite sides of the same tooth.

The head carrying the work-spindle is given a feeding movement about a vertical axis coinciding with the apex of the pitch cone or center of the machine. When the cutting tools have reached the proper depth, the work-head swings back to clear the tools for indexing. This motion is transmitted through a worm on shaft *A*, a worm-wheel segment, and a circular feed-rail *B* extending around the base of the machine to the work-spindle head. The feeding movement is automatically disengaged when the tools reach the bottom of a tooth space, and there is a dwell at this point before the gear swings away from the tools, so that the tools make one complete stroke at full depth, thereby finishing all of the teeth to the same depth. The extent of the feeding

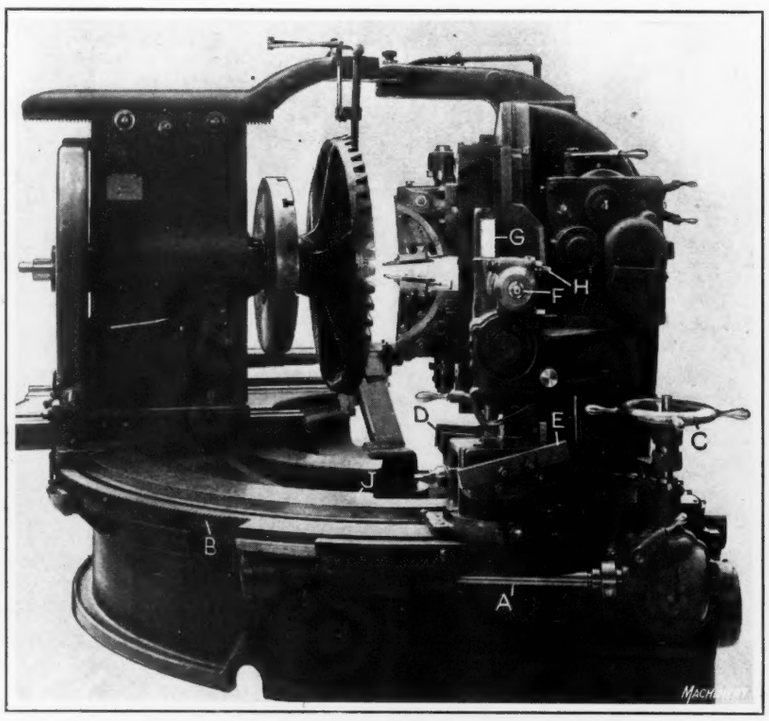


Fig. 11. Bevel Gear Planer of Two-tool Form-copying Type

movement is regulated by adjustable dogs on a graduated dial connected with the reversing mechanism. The hand-wheel *C* may be used for feeding by hand as, for example, when finishing the bottoms of the tooth spaces. The rear view, Fig. 12, shows part of the indexing transmission; the casing at the right contains the change-gears, which regulate the indexing movement. This machine is designed to be set up readily so that it is adapted for a variety of gear-cutting operations within its range.

Arrangement of the Tool-slides

The two tool-slides are inclined in relation to each other on account of the converging form of bevel gear teeth the angle between the slides being varied to suit the gear. The axis of the pivot or bearing about which the tool-slides are adjusted coincides with the center of the machine. The tool-holders are also adjustable about an axis coinciding with this center. This latter adjustment serves to incline the tools relative to the tooth in order to locate them in the best working position. For instance, when cutting a gear having a small number of teeth the tools are inclined more than for one having a large number of teeth.

This machine will cut miter gears up to 38 inches in diameter and flat gears up to 48 inches diameter. The maximum diametral pitch is 1, and the maximum face width 10 inches. The machine can be so arranged that the tools cut when moving away from the center of the gear instead of cutting toward the center in the usual way. This reversal of the cutting stroke is an advantage in planing gears of large pitch cone angle, which tend to spring toward the tools. When planing from the center outward, the upper and lower tool-heads are transposed. The planing speeds and feeds are regulated by quick-change-gears.

How the Form or Templet Controls the Planing Tools

A single form or templet, in conjunction with a suitable mechanism, causes the tools working on opposite sides of a tooth (when taking a finishing cut) to gradually move further apart as the gear blank feeds inward. Fig. 11 shows a form *D* used for finishing a certain range of gear sizes and angles in the operating position. This form is attached to a small turret, which has on the opposite side a straight-edge *E* used for the roughing cuts, as described later. The swinging movements of both tool-slides are controlled by one form *D*. The turret holding the forms is connected with the circular feed-rail *B* extending around to the work-head, so that the form moves to the right as the work feeds inward.

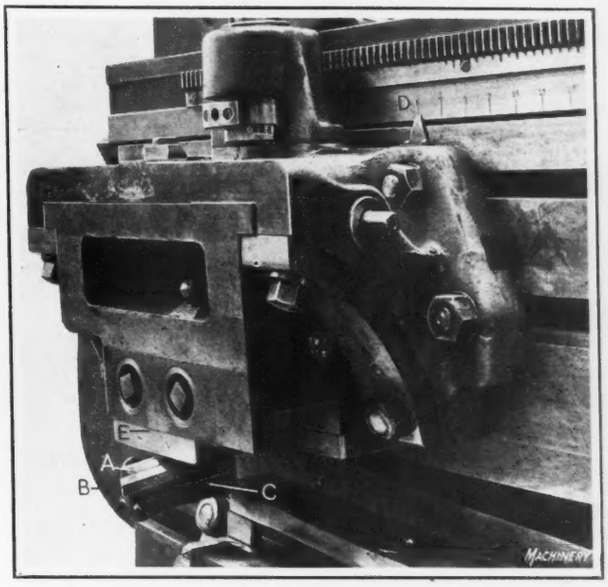


Fig. 13. Gage used for checking Position of Gear Blank

The form is engaged by a roller attached to the end of a vertical plunger *G*, which has rack teeth along one side. This rack meshes with a spur pinion which transmits motion through an adjusting worm to a bevel pinion on shaft *F*. The left-hand side of this bevel pinion (as viewed from the front of the machine), meshes with a segment gear attached to the lower tool-slide, and the right-hand side meshes with another segment gear connected with the upper slide. Consequently, as form *D* moves to the right, allowing plunger *G* to descend, the bevel pinion connecting with the segment gears is turned counter-clockwise, thus causing the tools to separate. The worm-wheel adjustment controlled by turning shaft *H* is used to regulate the initial angular position of the tool-slides in accordance with the tooth thickness required, graduated dials being used to determine the angular position.

The form is attached to a block on the turret having angular adjustment in the plane of the form. This adjustment makes it possible to use each form for a variety of gear combinations. Tooth contours differ for various sizes and angles, but by setting a form at different angles, as indicated by the graduations, the same form may be used for different sizes and angles within a certain range, and a set of twenty-five finishing forms serves for all combinations of gears for a given pressure angle. This angular adjustment is equivalent to one-half the angle subtended by lines extending from the apex of the back cone of the gear and coinciding with the sides of a tooth at the pitch line.

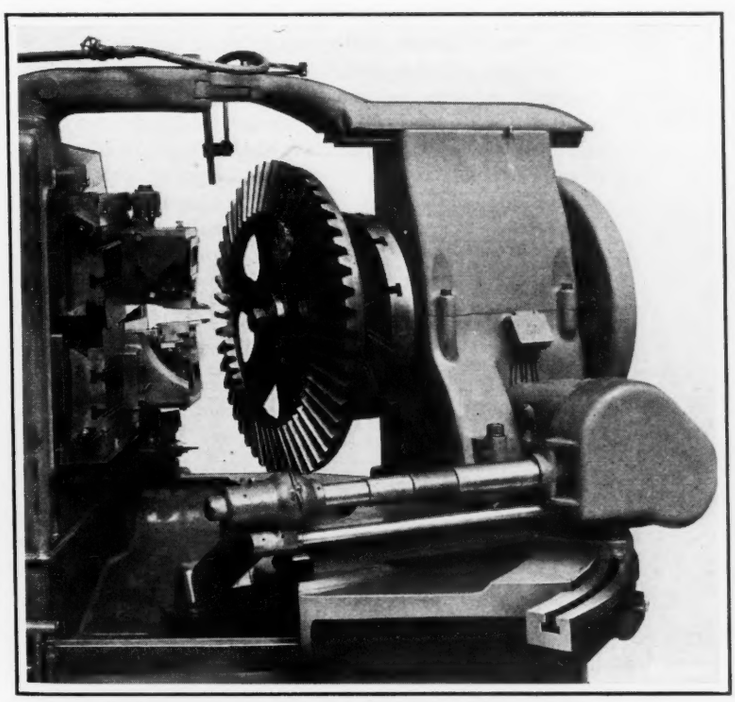


Fig. 12. Rear View of the Machine illustrated in Fig. 11

Adjustment of the Gear Blank

The head carrying the work-spindle is set in accordance with the pitch cone angle, as indicated by graduations on the base at *J*. In addition to the angular adjustment, the gear blank must be so located that the apex of the pitch cone coincides with the center of the machine. This endwise adjustment is obtained by shifting the work-spindle column along its base. When the gear blank is correctly located, the distance

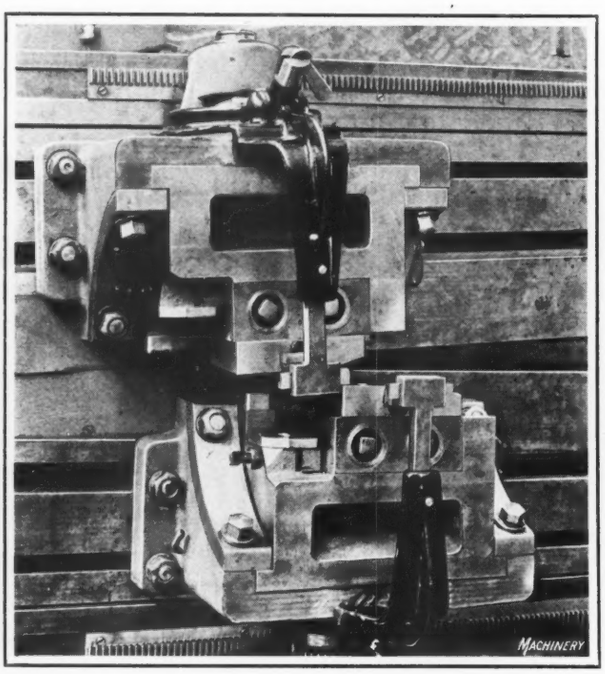


Fig. 14. Gages used for setting Tools

from the outer end of a tooth to the center of the machine, measured along the pitch line, equals the cone distance. A combination cone distance and angle gage is used to check the position of the gear blank. The gage is attached to the regular tool-holder, as shown in Fig. 13. There is a scale at *A* with a vernier on slide *B*, which connects with pointer *C*. The sliding part *B* is first set to the addendum or pitch depth of the gear to be cut. Then the work-spindle column is adjusted along its base until pointer *C* stands at zero, when the extreme outside edge of the gear is in contact with sliding scale *B*. When the gear has been adjusted in this manner, if the gear blank is not in the proper position endwise, or if it has not been turned to the correct size or face angle, such errors will be indicated by graduations at *D* and *E* representing the cone distance.

Setting the Planing Tools

With this machine a special fixture is provided for setting the tools off the machine. By means of this fixture, it is possible to locate the tools relative to the tool-holders so that when the holders are clamped in position on the clapper-box, the cutting point of each tool will be on the center line of the machine. The positions of the planing tools relative to the tool-holders may also be regulated by means of the gages shown in Fig. 14, which are placed on the tool-blocks for this purpose, and which have arms projecting down in front of the tools so that the latter can be set by placing them in direct contact with the gages. These tool gages on the machine are seldom used, because the special fixture previously referred to enables the operator to set the tools for a job at any time.

Taking Stocking Cuts on Two-tool Planer

The bevel gears ordinarily cut on this machine are finished from the solid. While it is possible to rough out the tooth spaces by the methods previously described in connection with single-tool machines, an effective method, especially for relatively coarse pitches, is indicated in Fig. 15. Square-nosed end-cutting tools are used, and these are set at angles that are equal approximately to the inclination of the sides of the tooth. One tool is inclined upward and the other downward, since they are used for roughing opposite sides of the tooth spaces. A straight form *E* (Fig. 11) is used.

When form *E* is in the working position and is moving to the right as the work-head feeds inward, it pushes plunger *G* upward, causing the tool-slides to move gradually toward each other; hence, two slots are formed as indicated by diagram *A*, Fig. 15. The gear then indexes an amount equal to the circular pitch, so that one tooth space is roughed out as shown by diagram *B*, the central part (indicated by the shaded lines) falling out after it has been separated by the tool. As this operation is repeated, a tooth space is roughed out at each indexing, to the approximate shape indicated by diagram *C*. This method of roughing would be employed for stocking out gears of the larger pitches. When it is practicable to use corrugated V-shaped tools, as when roughing cast-iron gears, especially those of the smaller pitches, two tooth spaces are stocked out simultaneously, and the indexing mechanism is set to index the gear an amount equal to twice the circular pitch.

TIME REQUIRED FOR CUTTING BEVEL GEARS ON GLEASON PLANERS OF FORM-COPYING TYPE

Size of Machine, Inches	Gear Material	Diametral Pitch of Gear	Number of Teeth	Face Width, Inches	Number of Gears Cut	Total Time,* Hours
24	Cast iron	3	54	2½	3	9
24	Steel	5	19	1⅛	6	5¾
24	Steel	12	18	1	25	18
37	Cast steel	1½	40	5	1	12
37	Steel	2½	26	2½	6	21
37	Cast iron	4	107	3	12	72
54	Cast iron	2	76	4	1	12
54	Cast iron	1¼	34	8	1	13
54	Cast steel	1½	50	6	1	17
77	Cast steel	1½	50	6	1	17
77	Cast iron	2	130	5½	1	20
77	Cast steel	4½†	47	11	1	50

Machinery

*The total time includes setting up the machine, stocking out and finishing.
†This figure gives circular pitch, in inches, instead of diametral pitch.

Time Required for Planing Bevel Gears

The accompanying table, containing data from actual practice, gives a general idea of the time required for cutting bevel gears on Gleason planers of the form-copying type. This table covers machines of four different sizes and includes data for cast-iron and steel gears of different sizes and pitches. The total time given in the last column includes the time for setting up the machine, stocking out, and finishing, and applies to gears that were stocked out on the same machine without removing the blank, which is the usual practice with planers of the templet type. The time necessary for setting up the machine usually varies from forty-five minutes to one hour.

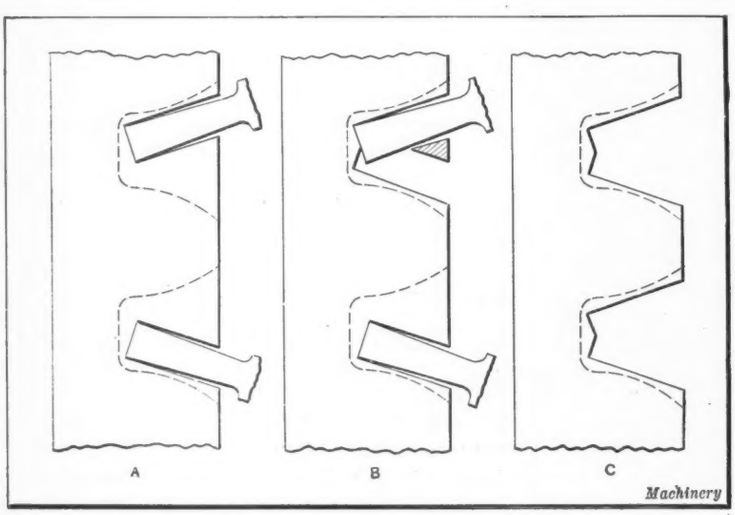
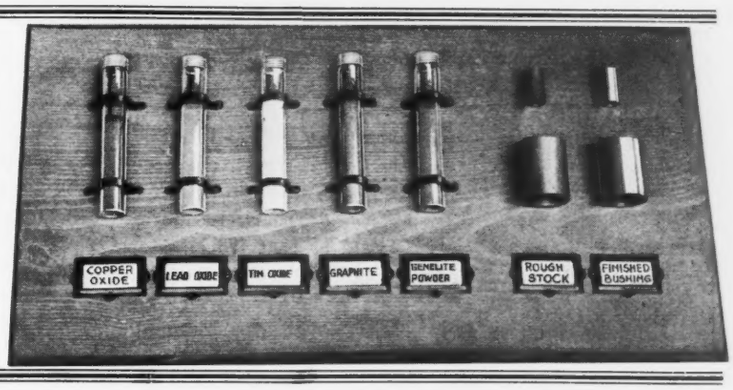


Fig. 15. One Method of stocking out Gears on Two-tool Planer

Genelite—A New Bearing Material

A Bronze Material Containing Graphite Evenly Distributed Throughout the Entire Mass

By E. G. GILSON
Research Laboratory, General Electric Co.



MACHINES in general wear out first at the bearings, and because of this, a great deal of time and thought has always been given to bearing construction. In recent years, however, with the demand for increased output and decreased maintenance cost, bearings have received even more attention than previously. A bearing may be considered as being composed of three parts—the journal, the bushing or bearing material, and the lubricant. In improving bearings, little can be done with the journal, as it is usually a power-transmitting member and must have strength to do its work. This leaves the bearing material and the lubricant as fields for improvement in present type bearings, and while they are quite widely different, they cannot be wholly separated.

Composition of Genelite

In an endeavor to increase bearing efficiencies, the research laboratories of the General Electric Co., have produced a material called "Genelite," which is a high-grade bearing bronze, made synthetically. The novel feature of this material is the admixture of finely divided graphite with the bronze in such a manner that it is uniformly distributed throughout the mass in a volume proportion as high as 40 per cent. This uniform distribution is accomplished by mixing graphite with the powdered oxides (copper, lead, and tin oxides) composing the bronze, in a sufficient quantity to reduce the oxides and leave the desired amount of graphite after the reduction is complete. The mixture is then put through a reduction process, being kept in the powdered form known as "Genelite powder," until the final steps. These consist of pressing the partially reduced powder in heavy steel molds under a high pressure as nearly as possible to the desired size and shape, and then giving it a final heat-treatment.

When this material is polished it is similar in appearance to bronze, but it does not have the same physical characteristics. It is quite low in tensile strength, but comparatively high in compressive strength. This will be readily understood when it is considered that the material is a bronze sponge with graphite distributed through its pores. The distribution of the graphite may be seen in the photomicrograph, Fig. 1, which shows the material greatly magnified. The black parts of the illustration represent the graphite, and the white the metal. The even distribution of the graphite and the continuity of the metal structure are well shown. The graphite is so firmly held that it is impossible to wash it out; in fact, it can be separated only by complete disintegration of the metal.

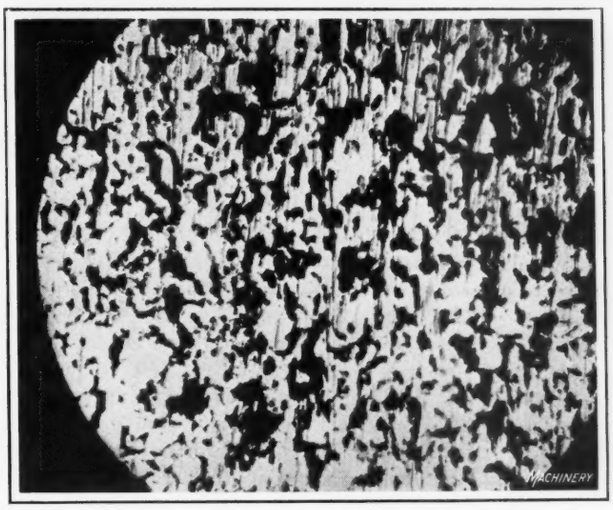


Fig. 1. Photomicrograph of "Genelite," showing the Distribution of the Graphite and Metal

Capillary Characteristics of "Genelite"

As a bearing material "Genelite" has three decided advantages: First, wear to both the journal and bearing is negligible. Second, it is impossible to melt out a bearing or to make it and the journal seize or weld together. Third, its porosity may be such as to allow an absorption of oil as high as 2½ per cent in weight. In many places "Genelite" can be taken advantage of to feed oil to the bearing surface by capillarity, the oil being brought into contact only with the outer surface of the bearing, there being no oil-holes nor grooves in the bearing.

This action is apparent from the experiment illustrated in Fig. 2, in which *A* is a cylindrical piece of "Genelite" resting in a glass vessel *B* which contains oil; *C* is a felt wick leading to the lower vessel *D*; and *E* is a weight that holds the wick in contact with the "Genelite." This arrangement will carry all the oil from the upper vessel to the lower. That this is done by capillarity through the pores of the "Genelite" part and not by creepage along the outer surfaces is shown by the facts that the surfaces remain dry and that if the "Genelite" part is replaced by a metal part, the passage of oil stops.

Bearings utilizing this principle have an advantage over wick-type bearings in that there is nothing to carbonize, like the end of a wick rubbing against a shaft—a condition which results in stopping the flow of oil. Neither does "Genelite" feed oil so rapidly that excess oil is thrown off, the capillarity holding it to the surface until it is used up. This feature makes "Genelite" ideal for application to vertical bearings which, from their nature, are difficult to lubricate, as well as to portable machinery.

In portable machinery it is usually difficult to keep oil in the bearings because of the constant change of position.

"Genelite" bearings used with high-speed spindles give results that are impossible to obtain in any other way. In one such instance, it was possible to use a soft steel spindle with greater efficiency than a hardened spindle and the old bearing. This seems to indicate that by the use of "Genelite," together with proper oil, higher spindle speeds can be attained with less attendant trouble than at present.

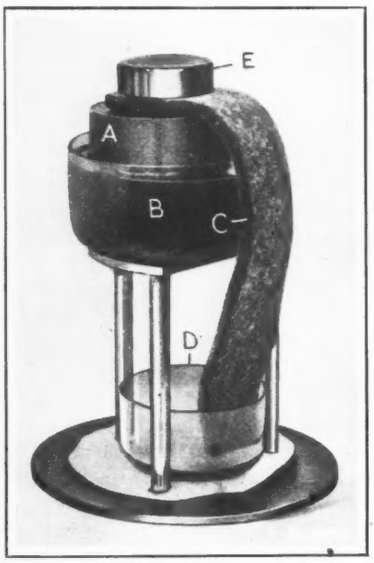


Fig. 2. Experiment that indicates the Capillarity of "Genelite"

The self-lubricating qualities of the material give it a great advantage in places that are hard to lubricate or that from their location are likely to be neglected. All applications of "Genelite" should be made with full consideration of its peculiarities. It does not machine readily, most of the machining operations being best performed by grinding. Therefore, it is most suitable for plain simple bushings. Because of its lack of tensile strength, it should be completely supported by its housing or backed up by a steel shell that will give it the necessary support. Also, for the same reason it is not practicable to make bushings as thin in section as bronze bushings can be made.

Results of a Test Installation

Although the first cost of a bearing material having the advantages of "Genelite" may be greater than of another material, this cost is more than compensated for in all places where the cost of maintenance or uninterrupted service are factors. A test installation was made in one factory where bearing failures were so common that the cost of repair, including that of rotating parts damaged when bearings failed, and of idle machinery waiting for repairs to be made, was a high percentage of the production cost. Two "Genelite" bearings were installed, one of which was lubricated by oil-rings in the standard manner. The other bearing, as an experiment, was a solid bushing without oil-holes or grooves. It was "waste-packed," having the oil-soaked waste in contact with only a small part of its surface.

It was expected that this bearing would work all right if the temperature could be kept below the disintegrating point of the oil used. But as there was no flood of oil through the bearing to carry away the heat and only about 25 per cent of the outside bushing surface was in contact with the housing, the facilities for dissipating the heat were very poor. The temperature of the bearings ran high and at full load the oil broke down, the volatile parts evaporating and leaving the asphaltic residue behind. Of course, under these conditions lubrication failed to exist and the temperature rose so much that fire extinguishers were brought to the job for fear that adjacent parts might catch fire. But the bearing continued to function until, finally, for fear of spoiling other parts, the machine was shut down.

When taken apart, the journal was found to be blue from the heat but otherwise in perfect condition, and the bearing was also unharmed. The journal was brightened up with crocus cloth, an oil-ring put in, the bearings reassembled, and the machine started off. It has given no trouble since, although operating continuously, and the set initially installed with the oil-rings has never given the slightest trouble. This experiment demonstrates the amount of abuse a "Genelite" bearing will stand.

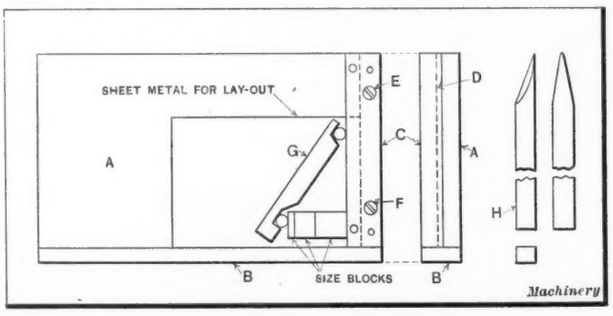
* * *

MAKING MASTER LAY-OUTS ON METAL PLATES

A very accurate and simple method of making master lay-outs on metal plates is to employ a special fixture like the one here illustrated. The fixture consists of the following parts: A cast-iron plate *A* machined on the top surface and along one edge; a steel strip *B* ground on one side and attached to plate *A* by flat-head screws; and a steel bar or straightedge *C*, which is ground on the inner edge and set exactly at right angles with the ground surface of part *B*. Bar *C* is held in place by dowel-pins and flat-head screws *E* and *F*. A recess *D* is cut in bar *C* to receive the sheet metal on which the lay-out is to be made. The two small holes on the left-hand side of bar *C* are tapped and provided with screws that can be tightened to hold the sheet metal in place.

By the use of a sine bar such as shown at *G* and standard size-blocks, angles and straight lines can be accurately laid out on the plate. A special knife-edge scriber *H*, the flat side of which can be held against the side of the sine bar, will greatly facilitate the drawing of fine lines. Very accurate center lines for locating the dividers can be struck with a needle point, using a magnifying glass to observe the work. If the knife-edge scriber and divider points are carefully stoned, very fine lines can be produced.

Sheet zinc has proved to be one of the best metals for master lay-out plates when properly prepared. To prepare this metal, first remove the coating from the side to be used, with a piece of medium grade emery cloth, and polish the surface sufficiently to remove any visible scratches. Then wash the polished surface with a solution of blue vitriol such as is ordinarily used in the machine shop, care being taken not to pour the fluid on the plate too rapidly. The best results can be obtained after a little practice by holding the plate under a stream of running water, while the blue vitriol is being applied with a saturated piece of soft



Equipment for making Master Lay-outs on Metal Plates

cotton waste or similar material. The plate is then allowed to dry thoroughly, after which a drop or two of oil is applied and rubbed lightly over the surface. This method will produce a very dark surface or one that is practically black. In drawing lines with either a needle point or the scriber shown at *H*, only a very light pressure is required.

Master plates produced by this method are used for complicated profile gages and similar work. These plates are ordinarily used only by the gage inspectors and are kept as a permanent lay-out record. All the necessary information, such as the title, drawing numbers, etc., is usually written on the plate with a needle point. The plates are cut to a standard size and filed like ordinary index cards.

J. E. L.

ADJUSTABLE-PLUNGER STOPS FOR FIXTURES

By EDWARD HELLER

In May MACHINERY, page 730, the design of spring plungers is discussed. The writer believes that the designs described in that article contain two objectionable features: (1) they extend above the working position when not in use; (2) they will jar loose, and although they are constructed to prevent their dropping down, they will jar up, which will affect the position of delicate work in the fixture.

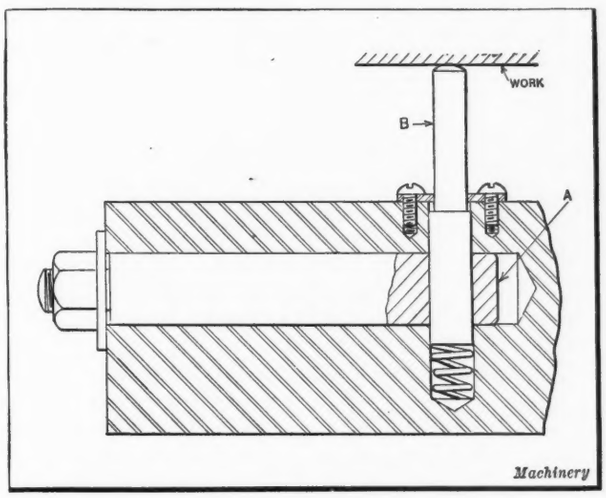


Fig. 1. Plunger Stop of Simple Design

A remedy for these two objectionable features is offered in the designs illustrated in this article.

A plunger design is illustrated in Fig. 1. The clamping member *A* is a piece of round cold-rolled stock, about ¼ inch larger in diameter than plunger *B*. One end of the clamp is drilled to receive the plunger and the other end is turned and threaded for a nut. A slight turn of the nut exerts a shearing stress on the plunger and it "stays put." But this design goes only half way in remedying the objections raised to the design mentioned; it does not offer an improvement so far as projecting above the surface of the fixture is concerned.

A design which overcomes this difficulty is shown in Fig. 2. This design was developed by the tool engineering department of the National Cash Register Co., where it has been used for a number of years and is regarded as the best stop of any design developed by that department. It has also been incorporated in fixtures made in other shops, and wherever the principle has been used it has given satisfaction. It may be modified slightly to suit the work at hand, and the parts standardized and made up in quantities. The stop consists principally of a plunger *A*, plunger bearing *B*, wedge *C*, wedge bushing *D*, clamp pin *E*, clamp rod *F*, clamp screw *G*, and dust cap *H*. The section view of the stop in the lower part of the illustration shows how the parts are assembled by means of screws and dowel-pins.

The illustration shows the stop in the working position. Before the work is put into the fixture, the wedge *C* is withdrawn, permitting the plunger *A* to drop down as far as the small set-screw will permit. After the work has been located on its positive stops in the fixture, the wedge is pushed in under the plunger, thus raising it into contact with the work. The wedge is advanced into this position by pushing on the knurled head of screw *G*, and as soon as contact is made, this screw is given a slight turn. This causes the clamp rod *F* to advance and force the clamp pin *E* up, jamming it against bushing *D*.

The enlarged views of pin *E* show that the spot in which the rod engages is drilled about 1/32 inch below the center of the clamp rod. The result is that when the rod is forced forward, it raises the pin and locks the entire mechanism in place. The pin is flattened on the lower end to fit into a slot in the lower side of the bushing *D*, to prevent turning. The construction also serves as a stop for the wedge *C*, preventing it from being entirely removed from its bearing in bushing *D* when withdrawn.

The main point in favor of this stop is the fact that the tightening is not done on the plunger directly. The tightening of the screw does not distort the set-up, but simply locks the whole mechanism in the required position without exerting any pressure in addition to that applied when advancing the wedge. The first impression may be that the design is expensive, but when one considers the details it will be apparent that this is not so.

The plunger is simply a piece of drill rod with the ends finished to length and machined with a flat for the set-screw. The wedge member is also a piece of drill rod with one end cut away from the center line at an angle of 10 degrees and the other end drilled and tapped to receive the parts contained in the operating end. Bearing *B* and bushing *D* do not need to fit very accurately in the fixture casting, nor do the drill rod members which work in them need to fit very accurately. In fact it is desirable to have a liberal working clearance for these two members. The dust cap *H* is made of any soft metal and pressed on the plunger.

When such a stop is made a standard construction, all fixtures are built so as to keep the work a certain height *J* above the fixture base. Every part of this stop can then be made up in quantities. The only variation that must be taken care of in a standardized application of this plunger is the distance *K*, and this is done by making the wedge *C* in two pieces, as shown at *L* and *M*, and making these of standard size. A variable connecting link *N* is then used to take care of the variation in length. Of course, the link must be made to suit each case.

The nicety with which this stop works is difficult to describe. It is more sensitive than anything that the writer has encountered in many years of experience. When clamped in position it is as solid and reliable as a solid stop. The writer has seen milling fixtures for handling various flat and delicate castings equipped with as many as twenty of these stops, arranged all around the fixture. The time required to tighten up all these stops was well spent, as the work produced was practically perfect.

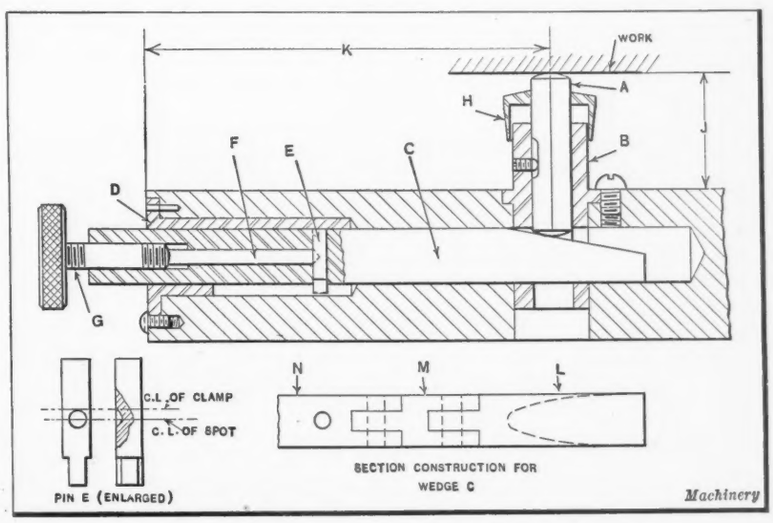


Fig. 2. Design of Plunger Stop that contains Special Features

Grinding in Foundry and Steel Mill

Types of Grinding Machines Used in Foundries—Wheel Selection for Snagging—Arrangement of Cleaning Room—Wheel Efficiency and Grinding Costs—Records of Wheel Costs—Billet Grinding

By the Engineering and Educational Departments of the Norton Co., Worcester, Mass.

ALL castings poured in foundries must be "cleaned" before shipment. In this cleaning process, grinding is very important, both in the cast iron as well as in the steel foundry cleaning room. This grinding or "snagging," as it is usually called, consists of removing from the surface of the castings any irregularities and projections left after the gates and risers have been broken or cut off. In addition, many castings have a protruding fin which is formed when the molten metal flows into the parting line between the cope and nowel of the molding flask.

Because of the efficiency of the modern special-purpose grinding wheel in removing metal rapidly and cheaply, it has often replaced pneumatic chipping (cold chiseling) hammers for this class of work, except for large castings of comparatively soft material and large irregular-shaped castings on which it is impossible to use a grinding wheel. Manganese steel and some other alloy steel castings, because of their extreme hardness and toughness, must be ground. Every foundry, therefore, has a cleaning room containing grinding equipment.

In the very largest foundries, as many as sixty machines of the various types, having grinding wheels from 6 to 24 inches in diameter and from ½ inch to 4 inches wide, are used. Some idea may be had of the scope of this phase of grinding from the fact that for every ton of steel castings produced, one dollar's worth of grinding wheels is consumed. The expense is less for cast iron, as would be expected, because of the greater ease with which this metal can be machined.

Grinding Machines Used in Foundries

The grinding machines of a foundry cleaning room are not of the precision type, because they are used only for rough offhand grinding. Four types are employed: Floor stands, bench stands, swing-frame, and portable grinding machines, each having its field of operation.

The floor stand (Fig. 1) should be of very rigid construction. Its mass should be great enough to absorb inherent out-of-balance conditions of the grinding wheel. Its bearings, if of journal construction, should be long and self-oiling with covers to protect them from grit and dust. The stand should be equipped with adequate wheel guards to protect the operator against wheel breakage, which can at the same time act as dust hoods if properly connected to an exhaust system.

Since machines of this type are generally equipped with two wheels, one on each end, it is of great advantage to have ample distance between wheels, that is, to have a long spindle so there will be a minimum of interference between operators and boxes containing castings. Floor

Fig. 1. Use of Floor-stand Type of Grinder for snagging a Casting which is supported by a Chain Hoist

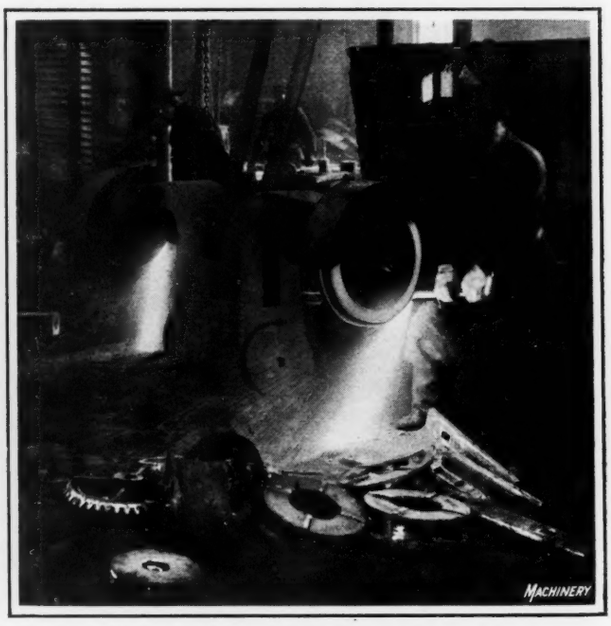


Fig. 2. Snagging Castings with Floor-stand Grinder having Ample Clearance between Wheels and Column

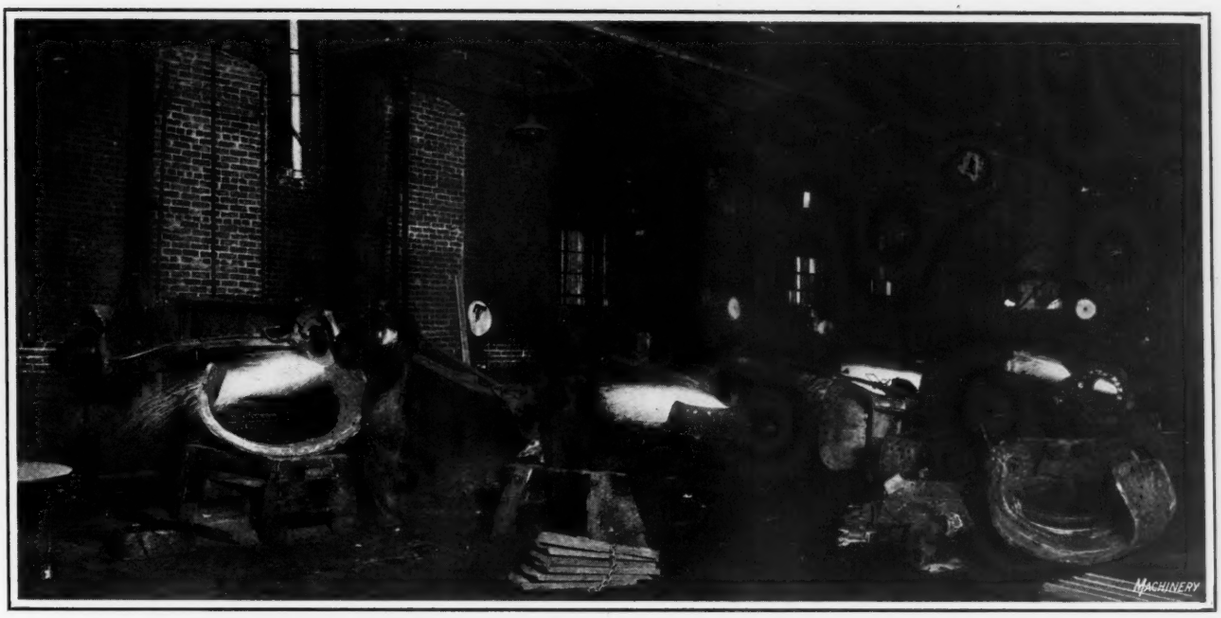


Fig. 3. Grinding Machines of the Swing-frame Type used for the Snagging of Castings

stands generally have grinding wheels from 12 to 24 inches in diameter and from 2 to 4 inches thick. The spindle may be driven by a belt or the stand may be a self-contained machine, with an electric motor at the center, the shaft of which is also the wheel-spindle. Castings weighing from 2 to 50 pounds are usually snagged on floor stands on account of the rapidity of production and the ease of handling work, of which mention will be made later. The floor stands that are shown in Fig. 2 are designed to provide ample clearance between the wheels and the frame of the grinder.

For smaller work on pieces weighing two pounds or less, it is more economical to use bench stands. These are similar in construction in every way to floor stands, but are smaller and have no pedestal.

Swing-frame Grinding Machines—Portable Grinding Machines

The swing-frame grinding machine was designed for the purpose of removing the fins, gates, and wires left by and in molding, from castings too heavy to be conveniently lifted by hand. One wheel only is mounted on a machine, and the arm on which the wheel is mounted has a large radius of swing and is designed, in some cases, to travel laterally on a track. Swing-frame machines are the heavy-duty machines in the foundry and are rigidly constructed. Great pressure of the wheel on the work is possible, because the operator bears his whole weight at times on the handles of the machine (see Figs. 3 and 4). Wheels from 12 to 18 inches in diameter and from 2 to 3 inches thick are commonly employed.

When on account of the size or the irregular shape of the castings, it is easier to bring the grinding machine to the work, portable grinding machines are employed. These machines are of such weight that they can be handled easily. The wheels used are generally from 6 to 10 inches in diameter and from ½ to 1½ inches thick. Although the driving power is usually electricity or compressed air (see Fig. 5), a flexible shaft is sometimes used for transmitting the power as shown in Fig. 6.

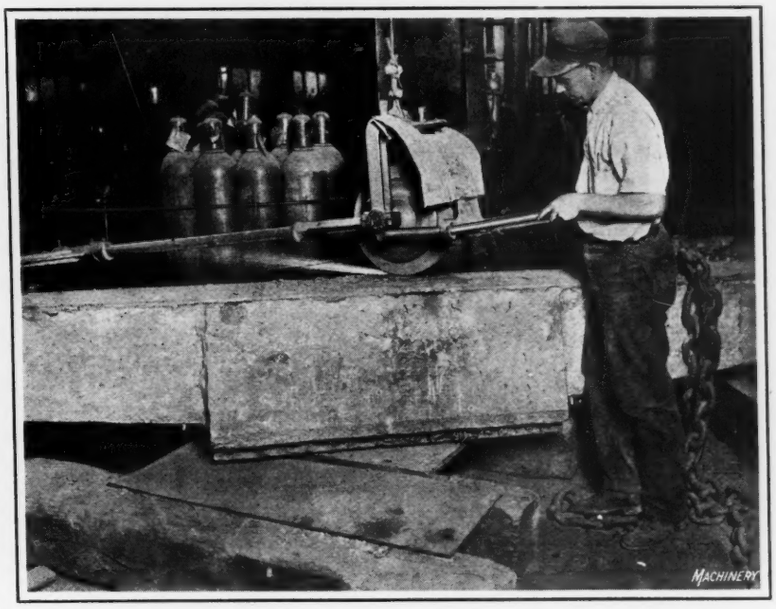


Fig. 4. Another Example illustrating Application of Swing-frame Grinder

Wheel Selection for Snagging

Modern grinding wheels are especially prepared and made in a variety of forms and compositions to meet the requirements of different kinds of work. For every class of grinding there is some wheel made different from others that will best perform the work. This difference in wheel make-up is due to the following factors that can be varied by the wheel manufacturer: (1) Size of grain; (2) grade of wheel (bond strength); (3) combinations of grains; (4) processes, materials, and different bonding methods, such as vitrified, silicate, elastic (shellac) and rubber; (5) abrasive temper. There are, however, certain wheels that have become practically standard for the snagging of castings. The characteristics of these wheels are: (1) Size of grain, 10 to 30; (2) grade of wheel, P to U; (3) process, vitrified; and (4) abrasive, regular alundum or crystolon.

This makes the selection for the foundry field less difficult; yet the range is still so wide that a thorough analysis of the material to be ground must be made. The choice of a wheel depends on: (1) Kind of casting (material); (2) type and condition of machine; (3) contact or size and shape of castings; (4) personal factor of operation; and (5) speed and size of wheel.

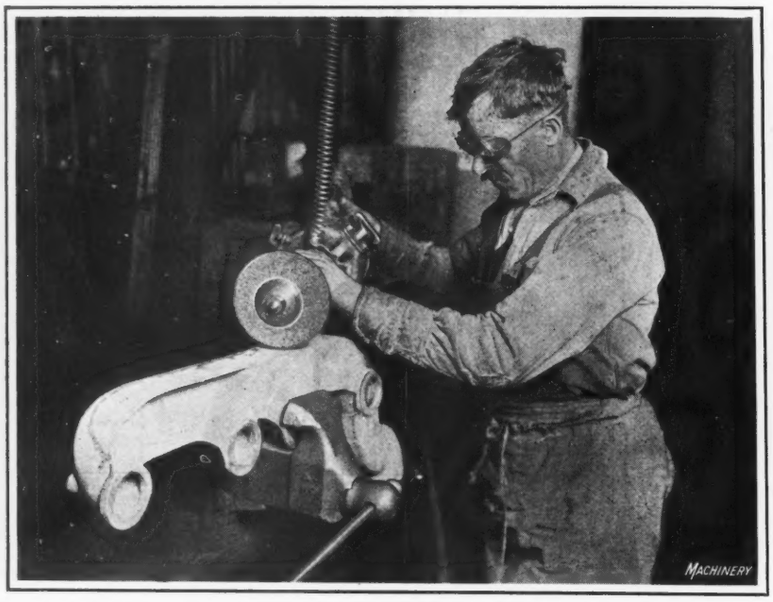


Fig. 5. Pneumatic Grinder with Spring Suspension

Cast iron is a metal of comparatively low tensile strength. Because of this and other physical properties, carbide of silicon, a very hard and comparatively brittle abrasive should be used in grinding it. On the other hand, steel castings require the use of aluminous abrasives which are hard and tough, because steel is a tough metal of high tensile strength and comparatively high ductility. Ductility of the material to be ground is an important consideration in wheel selection. The more ductile the material is, everything else being equal, the harder the wheels must be in order to perform efficient grinding.

Castings that present a narrow contact on the wheel face, such as stove castings and similar parts, require harder and finer wheels than castings that have a medium-sized or broad contact. The reason it is necessary to use harder wheels is that the effect of the narrow contact results in a dressing action, which causes the wheels to wear away more rapidly. Large sized castings are more efficiently snagged with wheels that are coarse, provided all the other conditions are equal.

The type and condition of the machine used is a factor that influences wheel selection. A heavy floor stand in good condition can use a softer wheel than a less rigid or a badly running machine. The latter will vibrate excessively, and this continual hammering of the wheel on the work disintegrates the wheel rapidly, unless it is hard. In either case, however, it is obvious that the efficiency of the machine is lowered.

A swing-frame grinding machine generally requires a harder wheel than a floor stand, because of the great pressure exerted by the operator, and the lack of rigidity of the wheel and work. The manner in which an operator uses a wheel brings in what is called the "personal factor." Some operators exert more pressure on the wheel than others, are more aggressive, treat the wheel more roughly, or in grinding language "punish the wheel." Operators paid on a piece rate plan are more likely to "punish the wheel" than those under other systems of payment.

A wheel running at a comparatively slow speed (5500 feet per minute is normal) acts softer than if run at the proper speed, and if the slow speed cannot be changed, this factor must also be taken into consideration. If quality of finish enters into the question, then quantity production must be sacrificed and a finer wheel employed.

Lay-out of Cleaning Room

Lost motion is waste in all classes and kinds of work. In processes of manufacture, the product should move in a continuous and prescribed path until completed. If machine equipment and general plant lay-out can be so arranged that the trucking is reduced to the shortest possible distance with least interference, then the arrangement is efficient, as is exemplified in some of the largest automobile plants. The lay-out of the grinding equipment in the foundry is of importance, because, with the proper arrangement, excessive handling and trucking of material can be prevented. The whole object is to keep the wheels of the grinding stand in contact with the castings during as large a part of the day as possible. The time spent in getting castings to the grinding wheel and disposing of them after grinding should be kept at a minimum.

The two important considerations are, first, the feeding of the castings to the grinding machines and, second, the removal of the finished pieces without interruption and interference, so that the work can be kept going continuously. To effect the first object, the castings must be placed within easy reach, so that the operator can grasp them with one hand and deposit them into a container with the other hand, the bodily motions being reduced as far as possible. This applies to small and medium sized castings only. To effect the second object, the machines must be so arranged that there is ample space for truckways. An electric lift truck, traveling on a suitably paved floor, and the use of boxes furnishes, perhaps, the best and quickest method of transporting castings. The boxes containing the castings should be of convenient size, so constructed that they can be handled easily by the lift truck, and mounted on wheels so that the grinding operators can move them without difficulty.

An ideal arrangement is shown in Fig. 7, which was primarily designed for a cast-iron foundry cleaning room. Here the bench stands are conveniently arranged along a well lighted wall, and the floor stands located near the center of the room, with ample trucking space around them. Good practice in the design of a cleaning room for steel castings is to have the castings enter at the middle of one side of the room. The heavy castings are then sent by a track or overhead rail system to one end of the building where the swing-frame machines are located; the lighter and small castings are carried in trucks to the other end of the building where the bench and floor stands are located.

Fig. 6. Grinder of the Flexible Shaft Type

After cleaning, all castings are conveyed to the center of the room opposite the point of entrance, where they can be inspected and shipped.

How to Determine what Grinding Wheels Give the Best Results

In order to use grinding wheels most efficiently, all the necessary factors should be considered. To some purchasing agents, the best wheel is the one that lasts longest; to the operator and foreman it is the one that cuts most rapidly, regardless of wheel life; but to the engineer and cost department it is the wheel that removes the most material in the shortest time and with the minimum wear. Other things being equal, production cost is the governing factor, and the best wheel is therefore the one that does the work at the lowest cost per unit of output.

To reduce this general statement of wheel efficiency to a working basis, three factors, namely, wheel wear, work done, and time consumed must be combined so that the best balance between them can be quickly recognized. This can be accomplished by reducing each to a "dollars per unit of product turned out" basis. The time element is introduced as an overhead variable. Thus if normal overhead is obtained per man and machine per hour, we can calculate the normal overhead cost per unit of product. Any increase in production due to a faster cutting wheel will decrease the normal overhead cost per unit of product and vice versa. The three cost factors to be added to obtain the total grinding cost per unit of product are then: Wheel cost per unit of product; labor cost per unit of product; and overhead cost per unit of product.

The wheel that makes the total cost per unit of product least, is the best wheel. A concrete example of the calculation of factors affecting wheel efficiency is shown by the accompanying table. From this table it will be noted that, although wheel No. 1 was used longer than the others (36 hours), and removed 72 pounds of steel, the cost per pound of steel removed was high as compared with wheel No. 3.

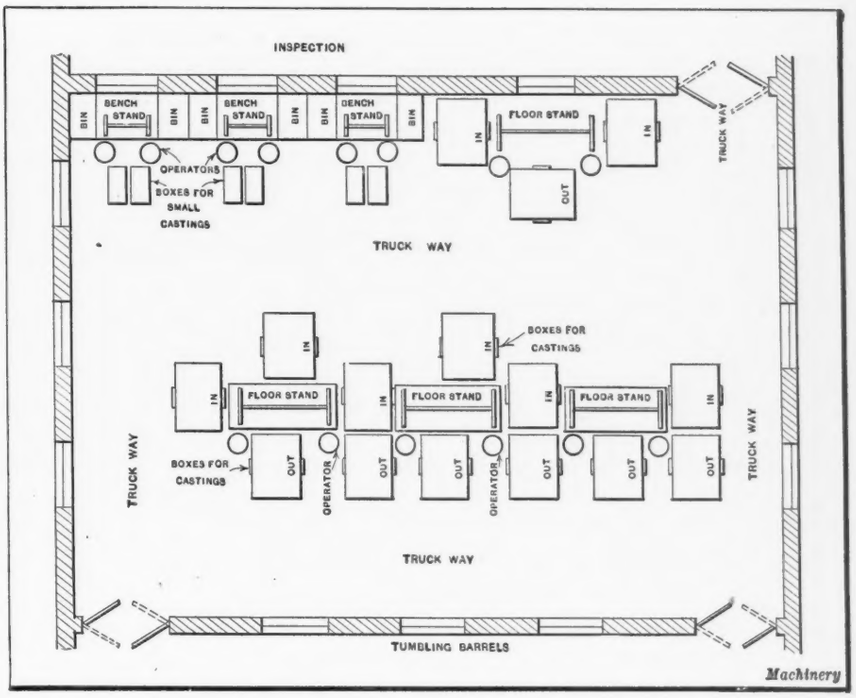


Fig. 7. Plan View, showing Arrangement of a Foundry Cleaning Room

EXAMPLES ILLUSTRATING METHOD OF DETERMINING GRINDING WHEEL EFFICIENCY

Wheel No.	Hours in Use	Diameter of Wheel when Removed, Inches	Wheel Wear, Cubic Inches	Net Production, Pounds	Material Removed, Pounds
1	36	11½	194	3021	72
2	6½	10	245	789	22½
3	14½	14¼	203	1825	62½

Wheel No.	Cost of Wheel Consumed, Dollars	Labor Cost, Dollars	Overhead Cost, Dollars	Total Cost, Dollars	Total Cost per Pound of Material Removed, Dollars
1	4.42	12.60	18.00	35.02	0.486
2	5.59	2.27	3.25	11.11	0.494
3	4.63	5.08	7.25	16.96	0.271

Dimensions of wheels used: Diameter, 16 inches; face, 2 inches; diameter of center hole, 2¼ inches.
Wheels may be worn down to 7½ inches in diameter, giving a possible wheel wear of 314 cubic inches.
Overhead (normal), $0.50 per hour per man and machine.
Net price of wheel, $7.16.

Machinery

The conclusion is that wheel No. 1 was too hard and slow-cutting to be economical. Wheel No. 2 was used only 6½ hours, removed 22½ pounds of material, and the cost per pound of steel removed was highest ($0.494). This wheel was so soft that the abrasive particles did not remain in the bond long enough to cause the wheel to cut efficiently. The gain of this wheel in speed of cutting over No. 1 was not enough to counterbalance the excessive wheel cost.

Wheel No. 3 was in use about twice as long as No. 2 and two-fifths as long as No. 1, but it cut at a very high rate, and removed material at a cost of only $0.271 a pound. Obviously this wheel is the most economical, and the saving which would be effected by its use in a year's time would be worth many times the cost of tests to determine the most efficient wheel. The form of data sheet shown in Fig. 8, for use by the workmen in comparing results obtained from different wheels, has been found to be practical and easily understood. The data used in calculating the table previously referred to was obtained from record sheets of this kind.

The Grinding Wheel in the Steel Mill

When molten steel is poured into molds, the resulting ingots almost invariably contain imperfections in the form of blow-holes, checks, slag inclusions, etc. These imperfections become very evident when the ingot has been rolled into a billet, and are then visible in the form of seams and cracks on the outside. Unless these seams and cracks are removed, they will appear as defects in products made from the billets, such as structural shapes, automobile parts, etc., and will make them dangerously weak. In the removing of these imperfections, large quantities of grinding wheels are consumed, and grinding is an important factor.

The seams and cracks in soft low-carbon steel billets are now being removed, for the most part, by means of pneumatic chipping hammers (cold chiseling). Although this method is very rapid it has disadvantages. The chisel of the chipping hammer has a peening action, and while the crack may appear to be entirely removed, actually the bottom of the crack may not have been reached. The seams in all alloy steel and high-carbon steel billets are removed by grinding. The general practice is to surface-grind the entire billet lightly, so as to remove the scale and make the seams and cracks visible, after which they are ground

out. Grinding insures the removal of the entire crack, because there is no peening action to cover up the fissures. Billet grinding, therefore, reduces the amount of grinding that would otherwise be necessary later on, after the billets have been rolled into bars. The swing-frame grinding machine is practically the only type used in the steel mill for billet grinding.

Cost-keeping is more important in connection with billet grinding than in the steel or cast-iron foundry, because of the larger amount of grinding done. An average billet has about 2 per cent of its weight ground off, and sometimes the amount of the material removed is as great as 10 per cent. When one considers that an average billet weighs about 200 pounds, it can readily be understood that, to remove 20 pounds of steel by grinding, necessitates a large consumption of wheels and makes it essential that efficient wheels be used.

Machine Number	
Wheel	
Size	
Time Mounted	
Hours Run	
Diameter when Removed	
Wheel Wear	
Weight of Billet before Grinding	
Weight of Billet after Grinding	
Material Removed	

Fig. 8. Data Sheet used for checking Results obtained from Different Grinding Wheels

Wheel Cost Records

Not many years ago wheels were purchased because of their lasting qualities, but exhaustive tests have conclusively proved that the purchase of wheels governed solely by length of life results in a loss of thousands of dollars yearly to consumers. The loss is due to the fact that labor and overhead rates per hour are constant, and that long length of wheel life is secured from the use of very hard wheels which may be inferior as regards cutting action. It is cheaper to buy softer wheels that last fifteen hours and produce rapidly, than to buy very hard wheels that last fifty hours and cut very slowly. Obviously there is a limit to the degree of softness of the wheel—a critical point so to speak—beyond which the cost of production will be increased.

Fig. 9 shows these facts in graphic form. Curve No. 1 shows how wheel costs per ton of steel handled decrease with increased wheel life. Curve No. 2 indicates how labor and overhead costs per ton of steel handled increase when harder or longer lived wheels are employed. Curve No. 3, the summation of curves Nos. 1 and 2, represents total grinding costs and shows that they are lowest when wheels that have a life of about twelve hours are used. This, then, is the critical point. Curve No. 4 shows how production decreases when wheel life increases.

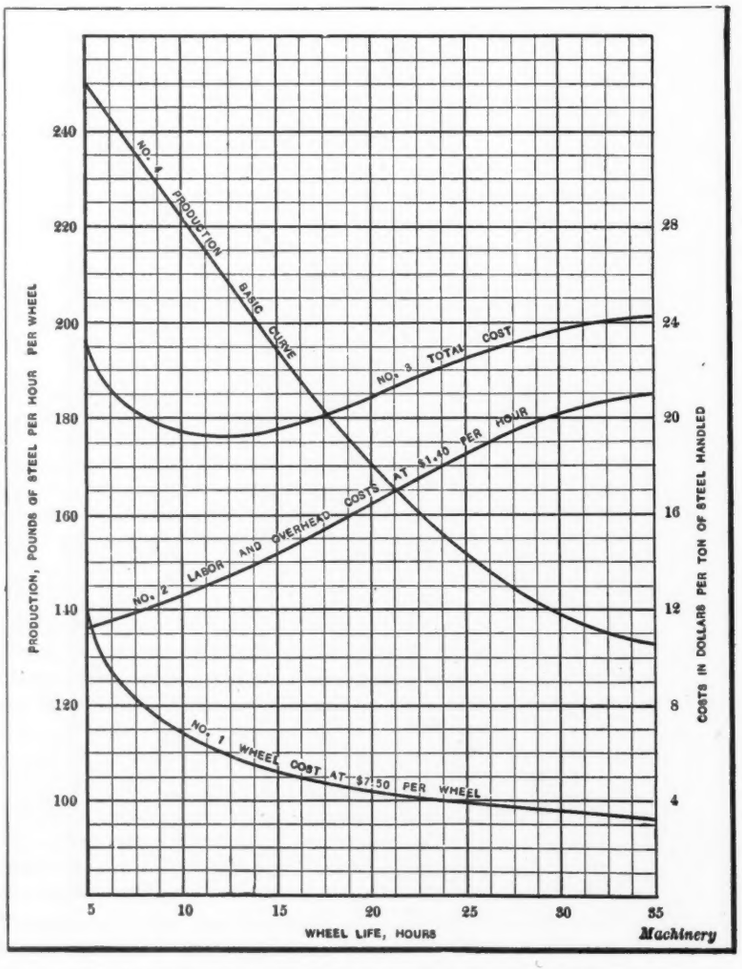


Fig. 9. Chart showing Relations between Costs and Production when grinding Steel Billets

Owing to the fact that an operator can grind only about fifteen billets per day, the manner of arranging and transporting the billets for the convenience of the operator, so as to eliminate actual loss of grinding time, is not of great importance. Billet grinding wheels average about 16 inches in diameter by 1½ inches thick, and range from No. 12 to No. 20 in grain size and from Q to T in hardness. They are made of an aluminous abrasive, since the material ground is steel of high tensile strength and comparatively great ductility.

* * *

PREHEATING CAST-IRON THERMIT WELDS

In order to compensate for the lower melting point of cast iron, as compared with steel, the Metal & Thermit Corporation recommends that, in preheating cast-iron sections preparatory to thermit welding, these sections be heated only a little more than is necessary to show color, such as a dull red heat. This practice has now been tried successfully in numerous cases, the most important of which was that of a thermit weld on a large cast-iron press head which required 1100 pounds of thermit. The weld was perfect, with good fusion to the edge of the collar, although the cast-iron section was heated only to a dull red heat.

It is believed that this point is very important to bear in mind and that operators will find that it will overcome difficulties which they may have experienced in welding cast iron. One might suppose that as the cast iron of the parts being welded is not quite so fully expanded at the lower temperature used, there might be a slightly greater tendency for hair line cracks to appear in the thermit steel collar, perpendicular to the line of break. In actual practice, however, this has not been found to be the case, probably because the expansion curve is much greater up to a red heat than it is from a red to a white heat, and the sections are fully expanded at the dull red heat. It is also true that the thermit steel heats and expands the sections with which it comes in contact, and therefore, the slight difference in preheating is negligible.

RELEASING MECHANISMS AND ADJUSTABLE STOP

By C. M. LINLEY

The disengagement of a toothed clutch can be accurately accomplished at a predetermined point in the traverse of a sliding machine member by an arrangement similar to that shown at *A* and *B* in Fig. 1. This design enables disengagement to be accomplished so quickly that wear on the clutch teeth is reduced to a minimum. The mechanism consists of a weighted lever *D* connected at one end to two links *E* which control the axial movement of the driven clutch member. When the clutch is engaged as shown at *A*, the opposite end of the weighted lever is supported by trip-lever *F*, but when lever *F* is tripped during the operation of the machine, the weighted lever falls, and thus forces the driven clutch member away from the driving member. The relative positions of the various details when the clutch is disengaged are illustrated at *B*.

A similar mechanism for releasing a worm from a worm-wheel is shown at *C*. The weighted lever has a surface at *G* that is concentric with the fulcrum of the lever. When the worm is in engagement, a lug on the bottom of the worm-box rests on surface *G* so as to hold the box in place. When the mechanism is tripped, surface *G* is pulled away from the worm-box, which drops and disengages the worm.

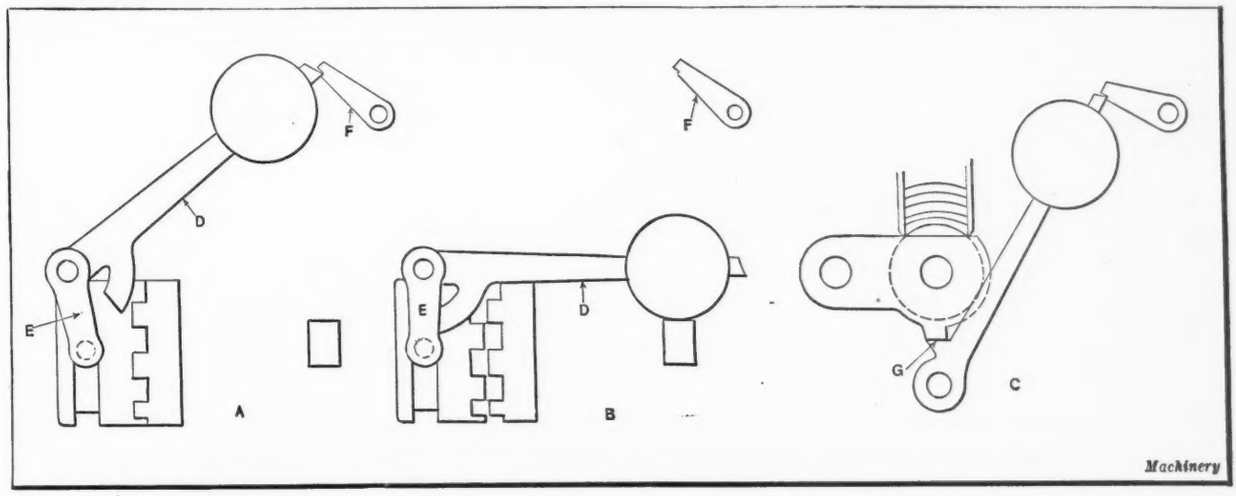


Fig. 1. Releasing Mechanisms in which a Falling Weight disengages either a Toothed Clutch or a Worm Drive

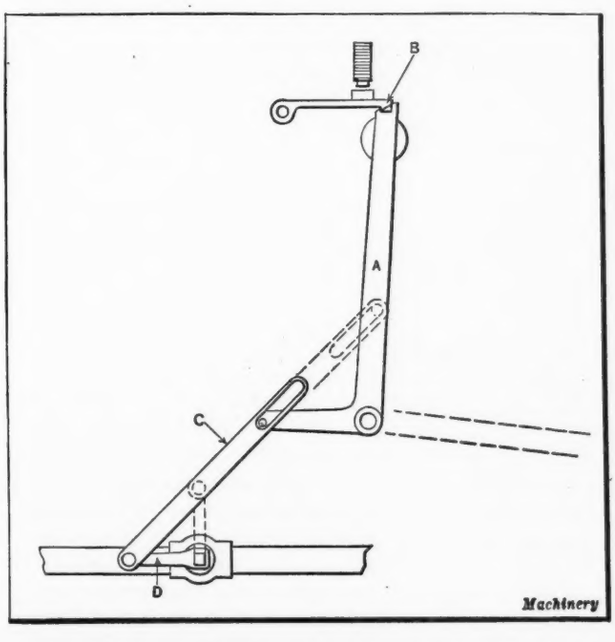


Fig. 2. Falling Weight Principle applied to closing a Gas Cock

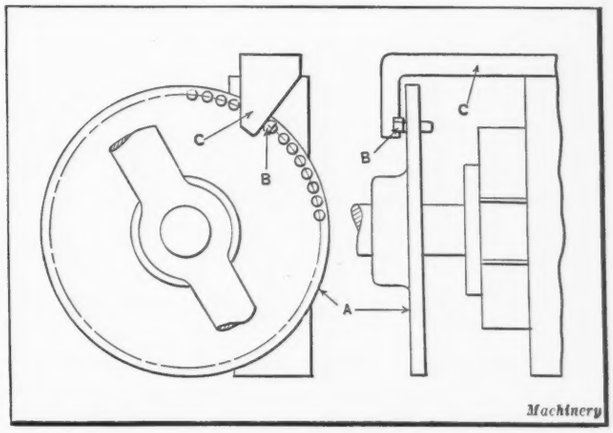


Fig. 3. Arrangement permitting Accurate Control of a Slide by inserting a Dead Stop in Holes of a Disk on the Screw

Fig. 2 illustrates the manner in which the same principle has been applied in an electric alarm clock to close a large gas cock at a certain time. The weighted lever *A* is held almost in a balanced position by catch *B*, the result being that the pressure on the catch is so slight that the feeble power of an electromagnet on the bell of the clock is able to move the catch sufficiently to release the weighted lever. As lever *A* swings on its fulcrum it pulls rod *C* upward and so operates wrench *D* on the cock. The dotted lines indicate the position of the different parts when the cock has been shut off. In each of the mechanisms described the falling weight causes a sudden and complete movement of the part to be operated, but one disadvantage of the principle is the difficulty of providing an automatic arrangement for resetting the weighted lever.

Dead stops are hardly practical in designs where automatic action alone is relied upon, and even when the sliding members which they control are operated by hand, they are not always as efficient as desired. Especially when the slide is actuated by a screw, one operator may force the slide against the stop harder than another and spring some parts so much as to cause appreciable differences in the dimensions of the work. Coarse or quick pitch screws are sometimes provided to obviate this trouble, but even then the results are not always satisfactory. In Fig. 3 is shown a dead stop that has been found to function well. Disk *A* is mounted on the lead-screw of the slide, and is provided with a number of holes spaced equidistantly around a circle near the edge. A stop *B* is placed in one of these holes to govern the movement of the slide, this being accomplished through arm *C* which is attached to the slide and makes contact with the stop after the slide has been moved to a

predetermined point. The disk revolves with the screw but has no axial movement. This method of placing stop *B* in a circle of holes provides a large selective range of fractional revolutions of the lead-screw. The head of the stop is so machined that a movement equal to one-half the distance between two holes can be secured by turning the stop 180 degrees. It will be evident that the head of the stop must not project a greater distance beyond the disk face than the lead of the screw.

* * *

INCREASED PRODUCTION FROM IMPROVED TOOLS

By D. A. NEVIN, Chief Engineer, Watters Corporation, St. Louis, Mo.

One of the surest and most economical methods of reducing manufacturing costs is to make improvements on those jigs, fixtures, and tools which are used in machining parts that are made in large quantities. It is the purpose of this article to show how closely production, or rather the cost of production, is related to tool design. Three types of drill jigs are illustrated, each better than the preceding one for the purpose set forth. The cast bronze spool, Fig. 2, is made in large quantities, and is finished all over on the outside and tapped in a turret lathe. The keyslot *A* is then cut on a hand milling machine. The last operation on the spool consists of drilling two 5/32-inch holes located diametrically opposite each other, as shown.

Fig. 1 shows the two-part jig which was first designed for drilling these holes in the spool, the position of which

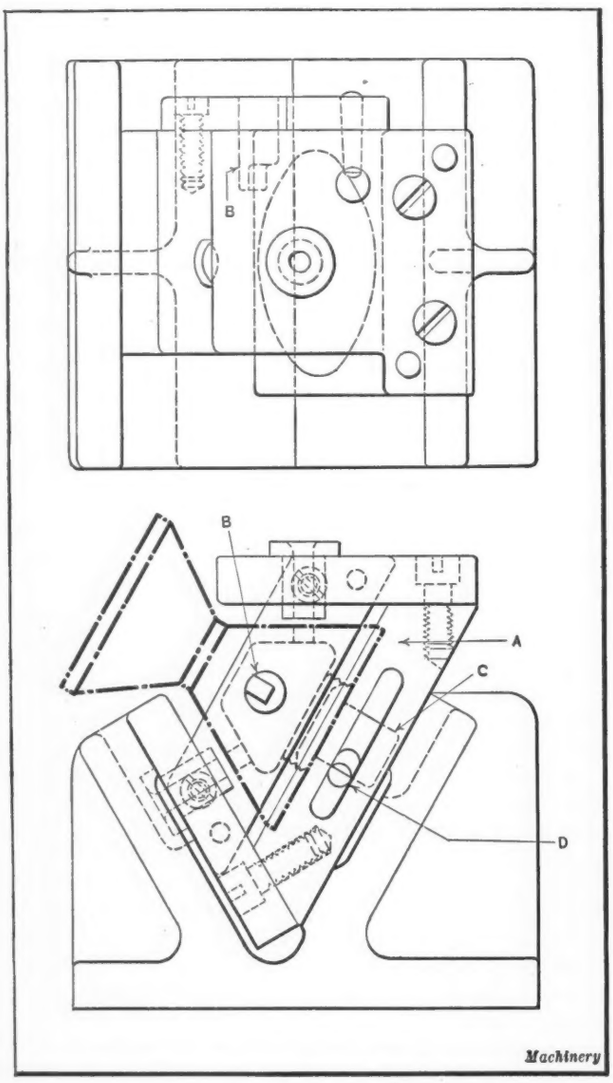


Fig. 1. Early Type of Jig used in drilling the Spool shown in Fig. 2

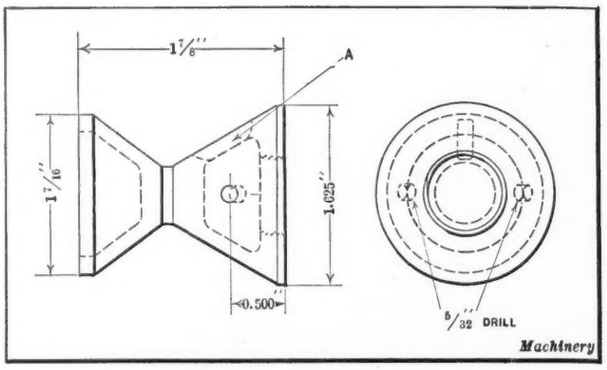


Fig. 2. Special Shaped Spool in which Two Holes are drilled, using Any of the Jigs shown in Figs. 1, 3, or 4

is shown by heavy dot-and-dash lines. Twenty of these jigs were constructed. The body was built up of machine steel and the cradle or base of cast iron. It was considered a very good tool, but would have cost less to construct if the body had also been made a casting, considering the large quantity of work required. The work is located in the pocket of the hardened plate *A*, pin *B* engaging the 5/32-inch keyslot. It is clamped by the threaded stud *C* which is operated by the pin-lever *D*. After one hole has been drilled, the body is removed from the cradle and inverted for drilling the other hole, in which position it remains while unloading and loading.

The type of jig illustrated in Fig. 3 was designed for the purpose of increasing production without employing additional drilling machines. It is a faster operating jig, has a better clamping device, and will remain more free from chips than that shown in Fig. 1. The operation of the jig is obvious, as the locating and clamping means are practically the same as in the jig shown in Fig. 1. Only two of these jigs were completed, this design then being superseded by the tilting jig shown in Fig. 4 of which fifteen were constructed. The production from these fifteen jigs was slightly greater than that obtained with twenty jigs of the type shown in Fig. 1.

The work is located in the same manner as in the other jigs. The nest plate *A* is made of steel and hardened. The base *B* provides bearings for the rocker or hinge pin *C* which supports the body *D* to which the work is clamped. The body is provided with liner bushings *E*, which are a sliding fit for the drill bushings, and which also serve to clamp the work. The bushings are operated as clamps by the equalizing levers *F* and are connected to the levers by the pins *G*. Slots for these pins in the heads of the drill bushings allow for the rotary movement of the clamping levers *F* which are pivotally mounted, as shown, on the jig body. The large end of the clamping lever is slotted and carries the large pin *H* through which is threaded a clamp screw with a knurled head. This clamp screw extends through the body and has a right-hand thread on one end and a left-hand thread on the other. A stop-pad *J* is threaded into the base of the jig on each side, and the corresponding stop in the body is in the form of a screw as shown at *N*.

This style of jig may be clamped to the table of the drilling machine. Its operation is rapid, as only a touch is required to rock it from one drilling position to the other. The clamping mechanism permits rapid operation and the drill bushings and other parts do not wear rapidly, as there is not sufficient variation in the finished diameter of the work to require much equalizing movement of levers *F*.

The efficient design of a tool of this class should be the result of an analysis of all the movements necessary to operate it, including loading and clamping, drilling, reaming, counterboring, etc., as well as unloading and cleaning. Much waste movement could be eliminated if drilling jigs

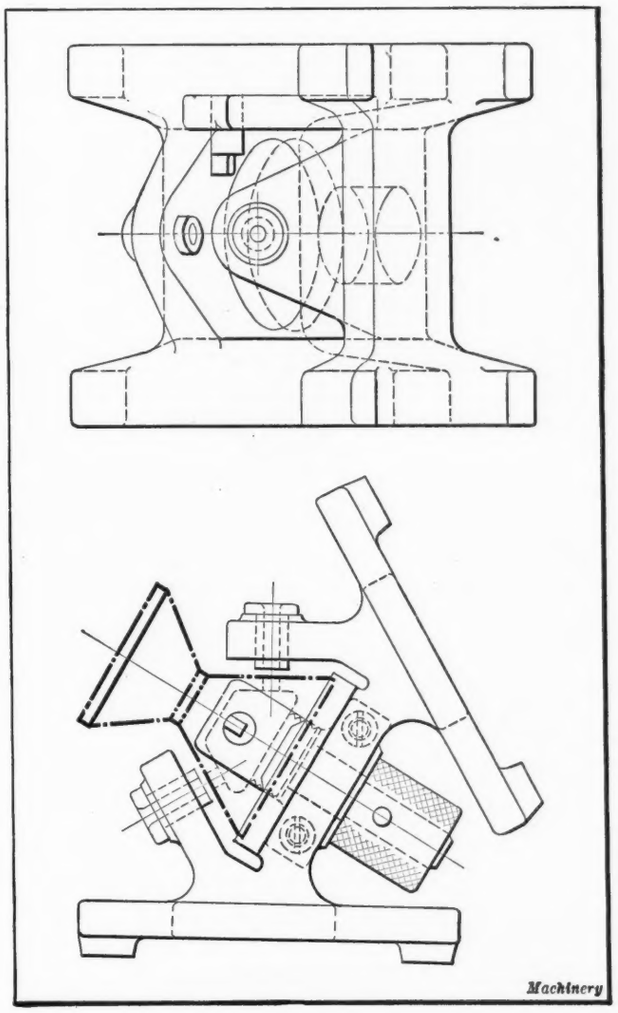


Fig. 3. Later Design of Drill Jig used for machining the Spool illustrated in Fig. 2

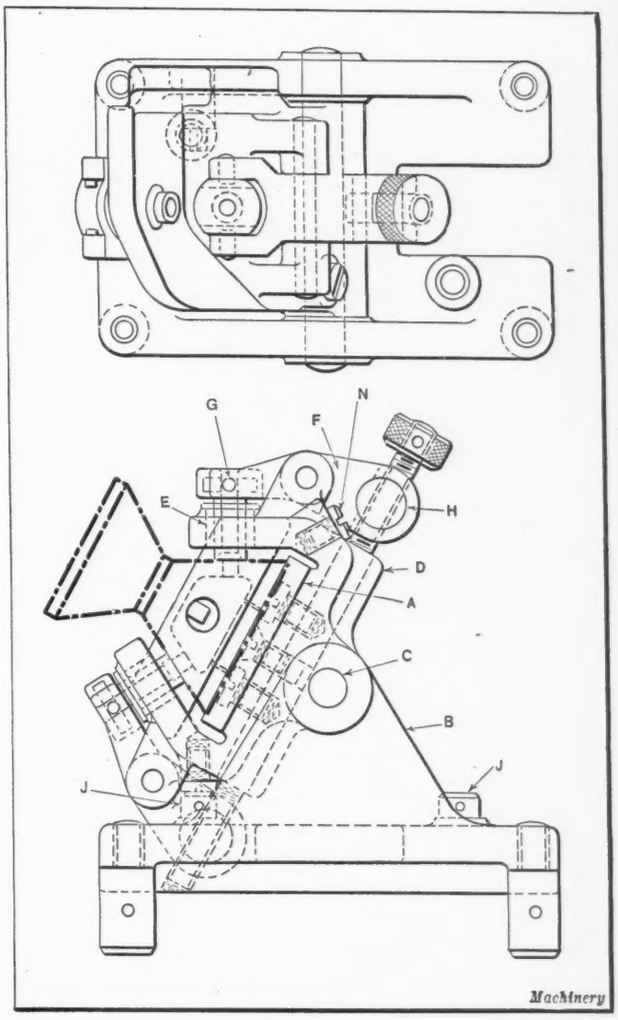


Fig. 4. Improved Design of Jig by Means of which Production was greatly increased

were clamped to the table when possible, and in some cases it pays to divide a number of drilling operations between two jigs to provide for this. When the jigs are fastened thus it is well to provide some quick method of removal for the purpose of cleaning, and on some classes of work it has been found to be advantageous to make use of compressed air for clearing out the chips.

* * *

TROUBLES WITH SPANNER WRENCHES

By DONALD A. HAMPSON

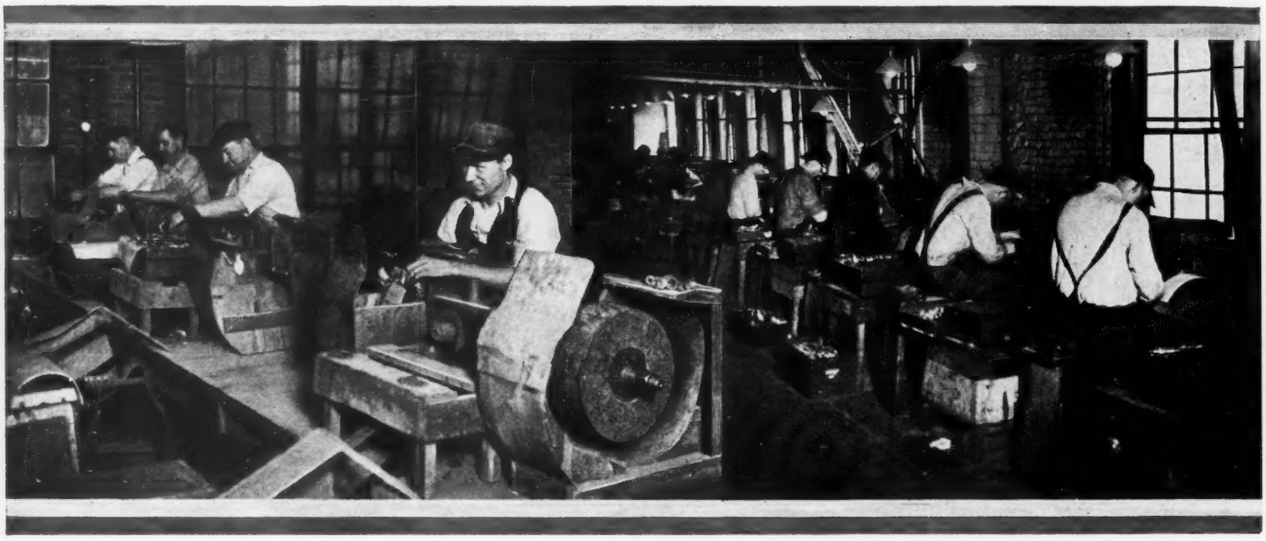
Round nuts drilled for pin wrenches or spanners continue to be used by the designers and builders of machinery. This type of nut, necessitating the use of a spanner, is very unpopular with the machine operator. Because of the difficulty of using a spanner, workmen often resort to a hammer and punch, which, of course, ruins the nut. The type of nut on which the spanner is used is of neat appearance, and this probably accounts for its continued use. If the spanner were made to encircle half of the nut, it would be more effective, but it would have no range of action and would be difficult to apply.

As now made, the spanner encircles about one-fourth of the nut and the handle is made short, which reduces the leverage and tends to raise the pin out of the hole in the nut. Therefore a hammer is frequently used on the end of the spanner in an effort to force the nut. The time lost due to this effort to start a nut with a spanner is considerable, and the loss in ruined spanners and spoiled nuts that have to be replaced makes the whole proposition expensive and unsatisfactory.

Then there is the adjustable spanner, which is as unsatisfactory in use as the solid type. Not long ago the writer saw a foreman throw one of these tools out of the window after a workman had unsuccessfully tried to hold it in place with one hand and move the nut with the other. Both the spanner and the nut were new. In place of the spanner, the foreman used a piece of ¼- by ¾-inch steel, 15 inches long, and in one end he drove a 5/16-inch pin which he then cut off so that it projected ⅜ inch. This improvised tool was of a shape that could be used in the rather inaccessible place where the nut was located. With this bar held tangent to the nut at the hole, one light hammer blow at the end of the bar loosened the nut that had successfully withstood the attempts of the workmen to move it. It is understood that this type of tool has since replaced the adjustable spanner in that shop.

In the case of a round nut, which is notched instead of drilled, a similar difficulty is encountered. The edges of the notches and the spanner key become tapered off, so that the wrench is ineffective. Workmen usually prefer the hammer and punch method of starting or tightening a notched nut, and the only thing in favor of the notch is that it presents a greater surface for the punch, which is ultimately used. In addition to the difficulty of using a spanner, it is also likely to become mislaid and lost, just when it is most needed. The spanner has probably remained in use because of its simple construction and neat appearance. Its inefficiency, while known to all who use it, has apparently been overlooked by the designers and manufacturers of machines. If round nuts, requiring spanner wrenches, were not used, one of the troubles of the machine shop would be eliminated.

Properties of Glue for Polishing Wheels



By BRADFORD H. DIVINE, President, Divine Bros. Co., Utica, N. Y., and President of the Metal Finishers' Equipment Association

ONE of the chief factors in a metal polishing room is the quality of glue employed; another is the manner in which it is prepared and used. Glue is susceptible of rapid deterioration and loss of holding power; this fact is not as well understood by polishers as it would be if mechanical rather than chemical action only were involved.

Failure to select, prepare, and use glue properly gives unsatisfactory results no matter what kind of polishing wheel is used or what the general working conditions are. This should not be taken to mean that polishing cannot be done with an inferior grade of glue, because in polishing rooms where this most vital element has not been duly considered glue of inferior quality is often used. But since glue is the tying element between the wheel and the abrasive it stands to reason that the real success of the operation depends on the glue and the method of using it.

Kinds of Glue Used in Polishing Rooms

There are three kinds of glue, namely, bone, hide stock, and fish glue. Hide stock glue is most generally used in the polishing industry. It is made from the skins of cattle, rabbits, and other animals. The stock is first limed to remove the hair, which causes it to swell and insures rapid extraction of the glue; liming also frees the hide of material which would impair the quality of the glue. The lime that is often in water in which glue is soaked preparatory to using, in addition to that already contained in the glue from the preparation process, reduces its value as a bonding agent.

Glues are often blended; for example, a sheep stock and goat stock glue make an exceptionally strong holding medium, and, when mixed with ox fleshings, form a glue which has more strength than a glue made entirely from rabbit or some other similar stock. The cheaper grades of glue are usually mixtures of bone and hide glues.

The color of glue, which is usually dark and hazy, may be lightened by the use of oxide of zinc, chalk, or talc, and these will produce a white or opaque fluid. Sometimes the use of these and similar substances in glue is an advantage in the polishing room, if the moisture or humidity is high, as when the factory is near a body of water. Under these conditions glue containing the substances mentioned will set easier and retain its strength longer. The use of such combinations for polishing wheels, however, should only be undertaken under the direction of those understanding the conditions.

Fish glues are not suitable for use in metal polishing, in spite of the fact that the most powerful adhesive known (isinglass) is a fish glue. Isinglass is marketed in various solid forms, and is sometimes mixed with hide stock glue to make belting cement and to bond bullneck polishing wheels in which disks of this kind of leather are glued together to construct a wheel. It is not used, however, to hold the abrasive to the face of polishing wheels.

Properties of a Good Glue for Polishing Wheels

The qualities which glue should possess in order to be valuable in the polishing industry are jelly strength, viscosity, and flexibility. Flexibility is the most important of these three qualities, because 95 per cent of all polishing wheels are flexible, or should be, on the surface. If the glue is brittle, it will break from the wheel. Jelly strength is determined by placing glue jelly at a certain temperature in a glass and allowing a wire weighted at the upper end to pass down through the jelly a predetermined distance in a certain time. The weight that is required to meet the predetermined conditions of distance and time is a measure of the jelly strength. Viscosity is determined by the time required for glue to flow over a given area, as compared with the time that water will flow over the same area. For example, the best grades of glue may require forty-five seconds to flow over an area that water will flow over in fifteen seconds. The viscosity is a measure of the adhesive power of glue.

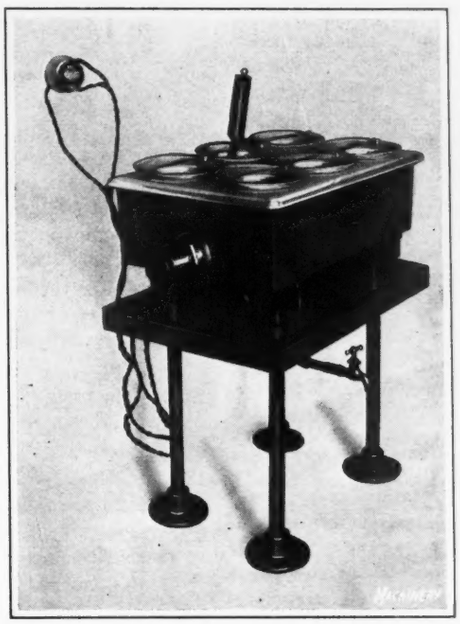
Importance of High-quality Glue for Polishing Wheels

The importance of using a good quality glue to hold the abrasive grains on polishing wheels cannot be emphasized too much. The heat generated in polishing has a tendency to melt the glue, and as a result the emery is lost from the wheel face. This point is of special importance in automatic or semi-automatic polishing machines, although designers of these machines have not always paid sufficient attention to it. Some provision should be made in such machines to keep the wheels cool so that the glue will remain hard and retain its holding power.

In combination with the crushing point of the abrasive, the melting point of the glue controls the permissible wheel speeds, so that with the use of a high quality glue, wheel speeds may be greatly increased. It is because of the fact that no standards have been adopted for using or making glues of a definite holding ability, that standards have not been established for the working speeds of polishing wheels.

Glue cools in two or three hours, but it does not set, so that wheels should not be used within forty-eight hours after gluing. If artificial means are employed to hasten the hardening of the newly set up wheel-head, the glue draws away from the abrasive grains, forming a pocket in which the abrasive soon becomes loose, instead of firmly holding the grain in bond as it should and will, if permitted to set in a mild atmospheric temperature. Artificial heat used to hasten the setting of glue on polishing wheels soon causes the glue to become useless as a dependable bonding material.

The character of the work to be polished should be considered in selecting the glue, as well as the grain and kind of abrasive and the size and speed of the wheel. For the coarser abrasives a heavy glue is required, while for the finer grains (above No. 80) a thin glue made by diluting the heavy glue works to better advantage. When surfaces are to be polished by using first a coarse abrasive below No. 46 and later a finer grain, say No. 120, the wheels should be set up with glues of proper consistency taken from separate pots, because putting the fine grains into the heavy viscous glue that is necessary for the coarser numbers will not produce a good working surface on the wheel. It is difficult to embed the fine emery properly in heavy glue; the abrasive tends to rest on the surface instead of penetrating it, thus giving the face of the wheel a packed appearance. For the best polishing, high-grade hide stock glue should always be used. There are now on the market a number of specially blended glues for setting up polishing wheels—glues that will hold the abrasive satisfactorily under normal working conditions.



Satisfactory Type of Glue-heater

Preparation and Use of Glue

Commercial glue is furnished in a cake form, in flakes, or pulverized; it should be kept in a dry place so that it will not mold. No matter what the form of the glue is, it should be soaked in cold water for several hours before it is heated. The water used for this purpose ought to be distilled; the drip from steam radiators may be utilized, if desired. The use of distilled water guards against chemical action due to impurities in the water, which may contain sulphur, lime, or iron, all of which are injurious to glue. If glue is soaked in hot water, it quickly decomposes and its strength is impaired. The amount of water that should be used varies with different makes and qualities of glue and should be stated by the maker of the glue.

Glue cake, ¼ to ½ inch thick, requires about twelve hours to dissolve; it should be broken into small pieces before being put to soak. Flake glue requires from six to eight hours, according to the thickness of the flake. Pulverized glue may be dissolved in from three to three and a half hours. The soaking process should not be hurried.

Glue should not be heated until it has been absolutely dissolved by soaking in cold water. After being heated, the glue may be diluted with hot water to obtain the required consistency. Glue should never be heated sufficiently to make it boil. It is also bad practice to prepare large quantities of glue at a time, because it loses its strength rapidly after being under heat for about four hours.

Satisfactory Type of Glue-heater

A satisfactory glue-heater should have ample accommodations for all the glue that will be prepared at one time, say, six or more glue kettles, as shown in the illustration. The kettles in which the glue is heated should be made of aluminum, and their size and number should provide for handling glue of various consistencies in sufficient quantities to last not more than four hours. Aluminum is the most suitable metal for glue pots because the scum on the glue does not adhere to the inside of the pots, so that they are easily cleaned.

A thermometer should be part of the equipment of a glue-heater, for the temperature at the bottom of a pot 6 inches deep should not be over 150 degrees F., which will bring the temperature at the top to about 140 degrees F. Higher temperatures than this destroy the adhesive power of glue. The pots should be thoroughly cleaned at least once each day. The glue that has become cooled should never be reheated, as reheated glue loses about fifty per cent of its strength. It is good practice to have a new lot of glue ready for use before the glue already prepared is consumed.

The heater shown has recently been placed on the market, and is intended to meet the requirements that have been established by research work on glue in polishing work. This heater is provided with a thermostat for the regulation of heat. A wheel-stand is also a necessary piece of the equipment; this stand should be so placed that there is but a small space between the glue pots and the wheel that is to be set up. Both the heater and the wheel-stand are adjustable for height.

Proportions of Glue and Water

The glue should be diluted more and more as the abrasive grain decreases in size. For instance, suppose that the glue has been melted in the glue-heater in the proportion of two pounds of water to one pound of dry glue, and that this is suitable for a coarse grain; then for finer abrasive grains, hot water can be added to give the right consistency. It is possible to perform practically all the operations included under the head of flexible grinding and polishing by using a glue of the jelly strength, viscosity, and flexibility necessary for the coarser abrasives and thinning it for the finer abrasives. Properly diluting this quality glue by the addition of water does not cause the heavy glue to lose its strength sufficiently to prevent it from holding the finer abrasives used in the finishing operations.

* * *

The Bureau of Standards has made some interesting investigations on reclaiming lubricating oils. The experiments show that with a commercial type of oil reclaimer oil can be reclaimed so it will be similar to new oil except as regards sediment. Further investigations are necessary to develop means for removing this sediment, which is probably carbon.

COLLECTING AND FILING DATA

What the Trade School can do to Aid its Students

By WILHELM KAUFMANN

As an example of how the trade school can bring its students into closer touch with the conditions in industry, we may consider in some detail just one phase of a draftsman's work. Most draftsmen find it indispensable to have a source of information to which they can refer when necessary and with which they are very familiar. This information is usually contained in a file of some sort, and the method of filing data for this purpose will be referred to as an example of how the trade school can acquaint its pupils with practical methods.

In every case where a graduate really studies the principles underlying his work he should be able to apply formulas and other data in a satisfactory way. For that reason handbooks and methods of filing data for use while at work should be among those subjects studied by the prospective draftsman near the close of the school term. Some practical hints cannot fail to bring results, and the last few weeks of school can be profitably given to work of this kind.

Any such data should be collected and segregated and be understood well enough to be applied correctly. The data should be checked by the prospective user before selecting it and he should refrain from making use of it until its accuracy and adaptability have been ascertained. The data in some handbooks may not conform to the standard practice in a particular factory, and this makes it necessary for the graduate to use caution in applying such data. Additional data of great value is constantly being printed and compiled which is not contained in handbooks. Some of this information can be applied immediately, and this should be kept close at hand as a ready reference. Some will be used only occasionally, while a certain portion possesses great potential value for future use. The student should be taught how to handle this data in a practical way.

In this connection there are three questions that the student should consider, namely, what to select for filing, where to file it and how to find it. There are three classes into which all data can be divided and filed — daily use, occasional use, and future use.

What to Select for Filing

Many men of ambitious nature make the mistake of starting to save data too far in advance of their mental and physical training. For example, an apprentice machinist may be ambitious to become a superintendent. If he starts saving data regarding systems, fire protection, laws, employment, etc., he will make a great mistake, for data gathered too far in advance is forgotten by the time it is needed or else becomes obsolete. While he is still an apprentice and is working on a lathe he should make a special study of lathes, and should keep his eyes and ears open and note facts about the tool-room and its machinery and thus prepare himself for the next step while becoming an expert lathe hand. This, in principle, is good advice for a beginner in any vocation.

Reading all kinds of valuable news and filing it is not the best aid to advancement. The mind should not be crowded with data, but should be given time to absorb important matter. The answer to the question of what to file is then: File thoughtfully, for application, all data pertaining to your present occupation and your next possible undertaking.

How to File

Each person must decide upon his own system for filing data. A very good one for the draftsman is given here to show the advantages of having the data arranged in files for daily, occasional, and future use. It is not necessary to have all the data in some standard form. This would take much time, and increase the chances of error. No material, not even a single data sheet, can be prepared in such an order or on such a size sheet that everybody and all conditions will be satisfied. If the questions "Is it understood?" "Can it be applied?" and "Is it correct?" can be answered in the affirmative, then the data should be filed. Material should be taken as it is found and left in that form unless enough time can be saved immediately to pay for condensing or otherwise preparing it for filing purposes.

Filing for Daily Reference—Some data clipped from magazine articles can be filed in a loose-leaf book of convenient size even though the data itself does not conform to that size. The data in this loose-leaf book should be that which is frequently used. In most cases an index is not necessary for the daily reference file, because frequent use enables the user to find the sheets desired without difficulty, especially since they are usually few in number. Material prepared in this way and for constant use is a great help in enabling a man to fit himself to solve the problems met with in business.

Filing for Occasional Reference—The data for occasional use should be put into a second loose-leaf book. These two books and a standard handbook are about all that the draftsman needs, except perhaps a small vest pocket index, if a drawer and portfolio file (the use of which is described in the next paragraph) is found necessary. Entire catalogues and other books should not be preserved for reference when only one or two pages are required; instead the information should be photographed or otherwise reproduced for filing in the loose-leaf book.

A handy method for the chief draftsman or designer is a single drawer letter file, ledger size, carried on a wheel-stand and containing portfolios for the data. The portfolios can be suitably marked for data relating to certain subjects. This form of file makes a good ready reference and can be used also to file unfinished work, order memoranda, etc. This type of file is cheaper than many loose-leaf books.

Filing for Future Reference—Inasmuch as magazine articles are not always of immediate application and are often used for occasional and future reference, it is advisable to clip the entire page where the article appears and file it in a portfolio marked "For Future Reference." It is also a good plan to draw a colored pencil line around the article in question; that is time enough spent upon an article of doubtful value. The file for future reference material, consisting of a drawer with portfolios for the data, should be kept in the home. All there is to filing is simply clipping the articles and dropping them into a portfolio.

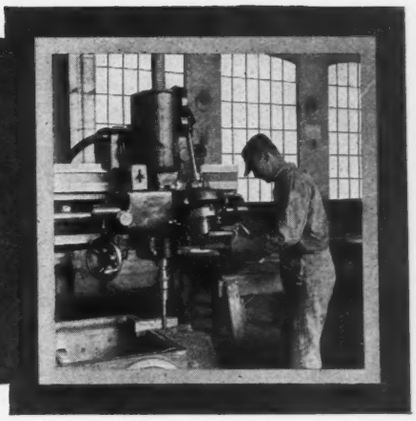
How to Find the Data

It is understood, of course, that an index is not needed for any file but that containing data for future use which is not often referred to except, perhaps, when taking up new work. However, to aid in locating data filed in portfolios, suitable titles should be indexed in a small pocket-size book, loose-leaf preferred, and the portfolios numbered. Although a card index may be used, it is not as convenient as the book. When prepared in book form, it does not require much time to look over several hundred titles, if they are carefully listed with about twenty titles per page. The index is especially handy for a draftsman who travels, because, when away, he can carry the small book in his pocket and refer to it to select material that he may need. The need for such data can be anticipated nearly every time, and it may be obtained promptly by telegraphing home, giving the portfolio number and the subject of the data.

* * *

The South African Government has recently announced an ambitious scheme of railroad construction which is receiving general approval in the country. The plans provide for 850 miles of new railroads in various parts of the Union, involving an expenditure of about $20,000,000.

Letters on Practical Subjects

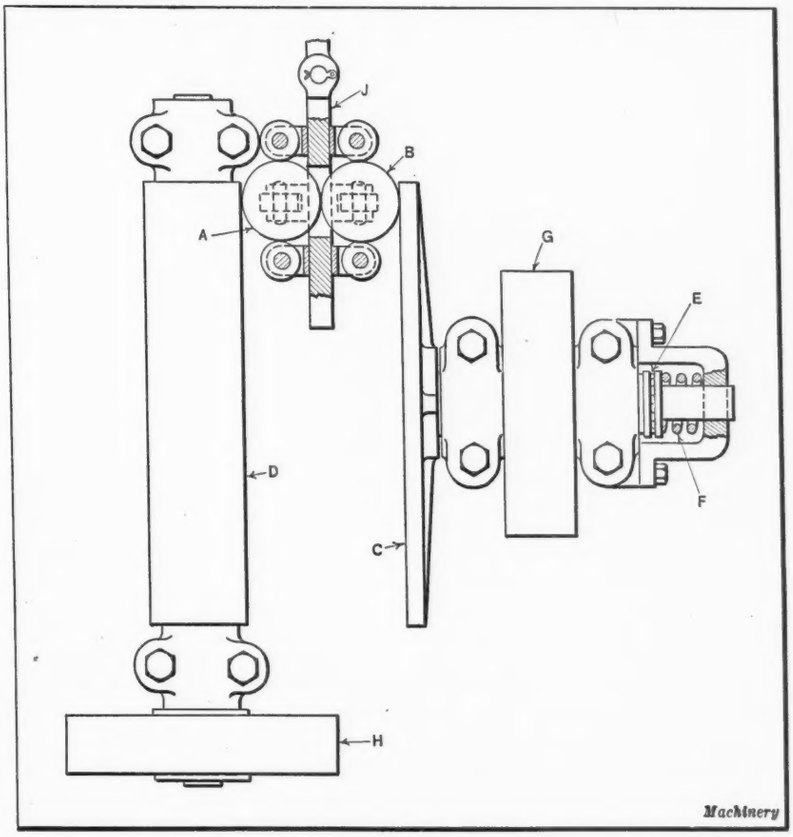


SPEED-CHANGING MECHANISM

It is often necessary to change the speed between the driving and the driven elements of a machine, and various kinds of mechanisms have been invented for this purpose. Change-gears, such as used on automobiles and lathes, are perhaps among the best known types of speed-changing mechanisms. Another type of speed-changing device which has been used to a considerable extent, consists of a friction driving disk and a roller which is driven by frictional contact with the driving disk. In this type of mechanism the speed of the driven roll is changed by moving the roll toward or away from the center of the disk, so that it is possible to obtain an infinite number of speeds within the range of the mechanism.

In the accompanying illustration is shown an interesting speed-changing mechanism of the friction type which was designed in 1915 for use in naval nautical instruments, about twenty being in actual use. In this application of the device the power transmitted is very small, say about 0.01 horsepower. The design is based on principles incorporated in an old English device, and mechanically considered, it is the most perfect mechanism for the purpose for which it is used that has ever come to the writer's notice. It has also been applied to mechanical fuel stokers, the power transmitted in this service being from one to two horsepower. At one time it was tried out in an automobile main drive, but even with glass-hard contact surfaces it would not stand up properly.

The writer has not made any tests to determine the heaviest duty for which a mechanism of this type could be used, but experience would indicate that it should not be built in sizes larger than two horsepower. For transmitting up to two horsepower, however, excellent results may be obtained. It is particularly useful when frequent changing of speed is required under conditions that would preclude the use of gearing for the purpose. A remarkable feature of this device is that the force required to effect a change from full speed in one direction to full speed in the reverse direction is so small as to be negligible, and this operation is unaccompanied by any jar or shock.



Friction Disk Speed-changing Mechanism by Means of which a Great Variety of Speeds can be obtained

As will be noted from the illustration, the device consists essentially of two balls *A* and *B* revolving in contact with each other between a driving disk *C* and a driven roller *D*. The shaft of the driving disk is mounted in a ball thrust bearing *E* back of which there is a spring *F*. The disk may be driven by a gear or pulley *G* or it may be connected directly to an electric motor or gasoline engine. The power is transmitted from the driven roller by pulley *H*. The two balls employed to transmit the power from disk *C* to roller *D* are mounted in a carrier *J* in which they are loosely held by small rolls mounted in brackets. The carrier is so mounted as to be capable of movement across the face of the disk.

The balls *A* and *B* are capable of two movements; that is, they may rotate on their own centers and also roll across the disk and roller between the two latter members. The disk, the balls, and the roller are all made of hardened steel. When the balls are near the edge of the disk the roller runs at its highest speed. Upon moving the ball carrier nearer the center of the disk, the roller gradually loses speed, until at the center it will cease to rotate. As the carrier continues to move, passing the center, the roller rotates in the opposite direction.

The pressure of the spring *F* is not excessive, and while the tractive force between the balls would appear at first to be small, there is actually no slippage in practice. This is in accordance with the law of friction which states that the amount of friction is independent of the amount of surface in contact but depends entirely upon

the pressure. An illustration of this law may be observed in the case of locomotive driving wheels, where the tractive force of, say, six points of contact with the rails, is sufficient to draw a heavy train.

Norfolk Downs, Mass. R. E. BATES

TOOL RACKS AND TABLES OF PEDESTAL DESIGN

Wooden cupboards, lockers and other machine shop equipment used for mechanics' tools and machine accessories, often present an unsightly appearance. Tool racks and shelves are of course indispensable in the shop, but the commercially manufactured product is often expensive and frequently not the best suited for the individual requirements, particularly as regards space. These tool racks and tables are usually designed with four legs or a closed bottom sometimes in the form of a cupboard. This construction presents another objection to machine shop furniture of this kind; namely, the unclean appearance of the floor surrounding the rack or table as well as underneath it. It makes it difficult for the sweeper to clean, and things are likely to be shoved under the bottom.

A serviceable and rugged tool rack of neat design, intended to overcome some of the objections noted with the closed-bottom four-legged type of equipment, can be constructed

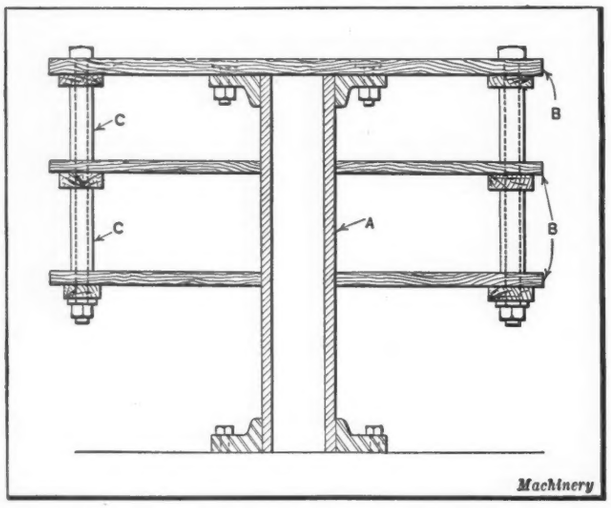


Fig. 1. Tool Rack with Supporting Column of Pipe

inexpensively as illustrated in Fig. 1. A section of scrap pipe *A*, 4 inches in diameter and 30 inches long, is threaded on each end and fitted with two flanges, one for the floor and the other for the top shelf. The lower flange is screwed to the floor with lag screws and if the floor is of cement, expansion shields are used for the screws. The shelves *B* are then made and provided with cross cleats nailed on the under side, as shown. The shelves are stripped over the pipe and supported by a top shelf to which the top flange is fastened with screws. Short pieces of small pipe *C* are used to space the shelves, through which ½-inch tie-rods or bolts are passed to hold the shelves firmly together.

A tool rack like this is easily constructed, inexpensive, and presents a neat and sanitary appearance. The space surrounding it may be cleaned easily, as the rack stands high above the floor, and light is not obstructed by any part.

The principles of construction shown in Fig. 1 are also applicable to tables for mounting small bench machines such as drilling machines, tapping machines, millers, and lathes. Wooden tables often used for this purpose are constructed with the aid of heavy angle-irons and they are of more or less clumsy appearance. They are not as compact and attractive as the pedestal type and are inherently dirt-catchers. The writer has often mounted small bench machines on tables made with pipe column bases, using single-pipe con-

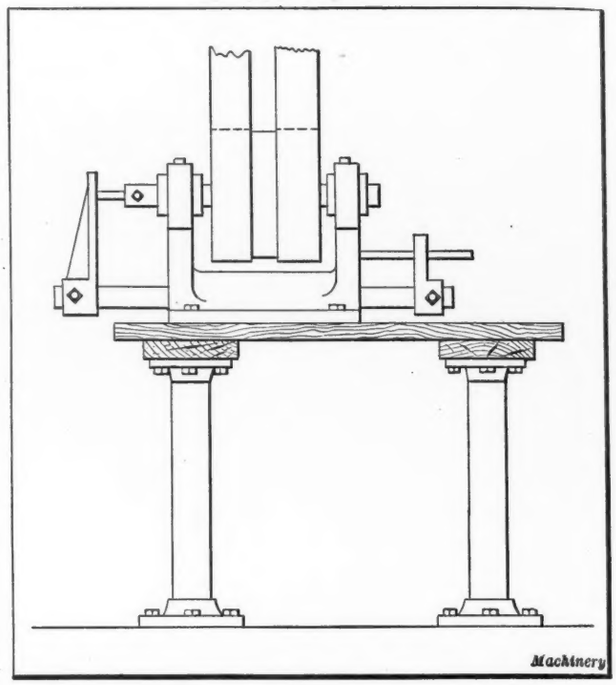


Fig. 2. Table of the Two-pedestal Type for Bench Machines

struction for the smaller machines and two-pipe construction for the larger ones. A table of the two-pedestal type on which is mounted a tapping machine, is shown in Fig. 2 The pipe is 4 inches in diameter, the table top 30 by 48 inches, made of 2-inch stock and the cross sills are 8 inches wide and 30 inches long, also of 2-inch material. This construction may also be used for assembling benches.

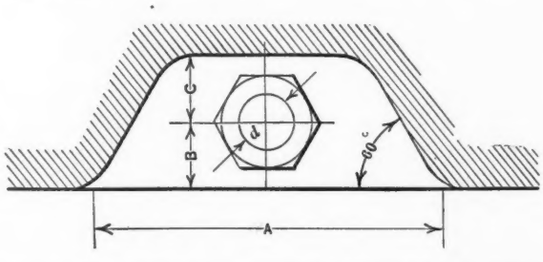
Allentown, Pa. JOE V. ROMIG

DIMENSIONS FOR WRENCH POCKETS

The table containing dimensions for wrench pockets which is presented herewith was made up by the writer for use in the drafting-room. It was formerly the practice to make a lay-out drawing and cut out new wrench templets each time a wrench pocket was to be shown on a drawing. The accompanying table makes this process unnecessary, and thus saves considerable time. The shape of the wrench pocket, as usually designed, is shown by the sectional view accompanying the table. The dimensions given in the table were worked out to give ample clearance for the drop-forged wrenches made by J. H. Williams & Co.

Groton, Mass. V. CHARUSHIN

DIMENSIONS FOR WRENCH POCKETS



d	A	B	C	d	A	B	C
½	3¾	⅝	⅝	1⅜	8⅛	1⅝	1⅝
⅝	4	¾	¾	1½	8½	1⅝	1⅝
¾	4¼	⅞	⅞	1⅝	9¼	1¾	1¾
⅞	5½	1⅛	1⅛	1¾	10	1⅞	1⅞
1	6¼	1¼	1¼	1⅞	10¼	2⅛	2⅛
1⅛	7	1⅜	1⅜	2	10½	2¼	2¼
1¼	7¾	1½	1½				

Machinery

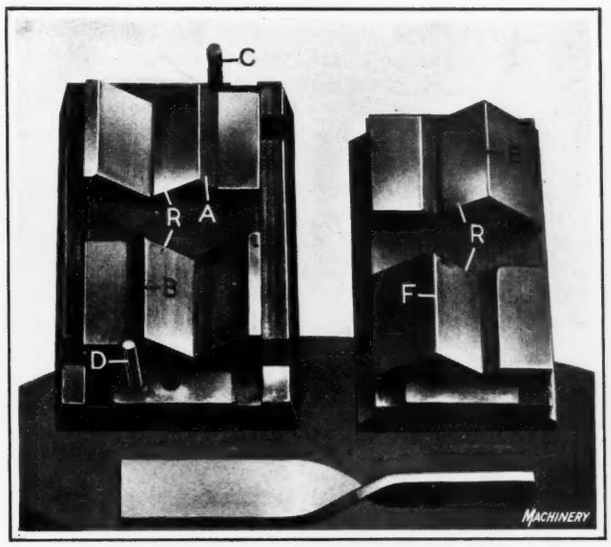


Fig. 1. Die and Punch for twisting Flat Stock

TWISTING DIE FOR FLAT BAR STOCK

The die shown in Figs. 1 and 2 was designed and made to twist flat bars, although the principle can be applied in other types of dies, for twisting blanks of various shapes and sizes. The die is very rugged and will withstand any strains that an ordinary V-shaped forming die will stand. It is very simple in construction and action, and can be designed to give the stock either a right- or a left-hand twist of any desired amount. The work is laid on the die in a horizontal position so that it rests on the edges *A* and *B*, Fig. 1, and against the gage pins *C* and *D*. A stop (not shown) is employed to locate the work endwise. When the punch descends, the points or edges *E* and *F* strike the work, forcing the edges downward.

At *G*, Fig. 2, is shown diagrammatically, a section of the work in the position it occupies at the completion of the stroke. The dotted lines at *H* show the position of the same section at the beginning of the stroke. The lengths of the different sections of the work can be varied by changing the lengths of members *A* and *B*. The length of the twisted part can be varied by changing the distance *J* between the members *A* and *B*. Although the die here described was designed to make but one twist, any number of twists can be obtained by adding more members such as *A*, *B*, *E* and *F*.

The inside edges *R*, Fig. 1, of the die and punch members over which the different sections rub when being twisted, should be rounded. This rounding of the edges must be considered when designing the dies if the twisted parts are to have the correct length. The dimension *K*, Fig. 2, should be the same as the width of the work so that the edges of the work will be automatically kept in proper alignment.

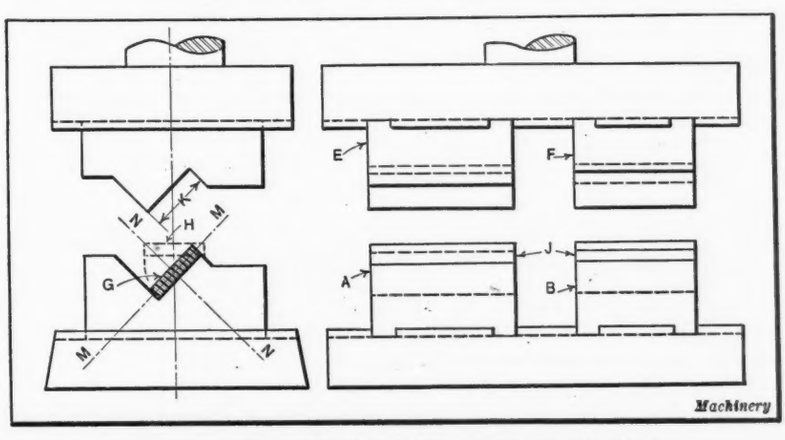


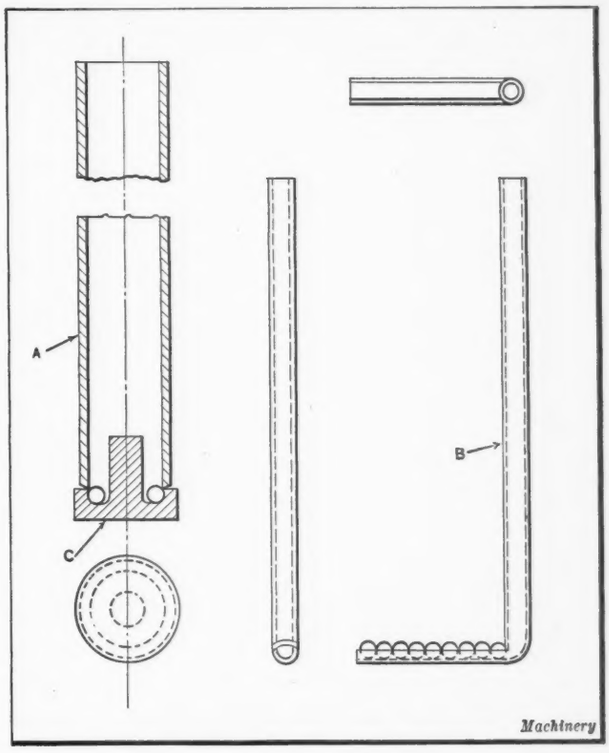
Fig. 2. Assembly View of Die for twisting Flat Bar Stock

By exercising care in laying out the die-blocks and keeping the blocks properly centered on the point of intersection of the center lines *M-M* and *N-N*, all the members can be machined from one piece at one setting, the piece being parted to make the required number of die members. The same practice, of course, applies to the punch-blocks.

Streator, Ill. WILLIAM DAUBLE

ASSEMBLING BALLS IN BEARINGS

The assembling of the balls in the race of a built-in ball bearing often proves a time-consuming job. A special mechanism, the manufacture of which was under the writer's supervision, had an inaccessibly located bearing of this type in which nine steel balls were assembled. In order to facilitate the assembling operation, the writer designed a device for automatically counting or selecting the correct number of balls and conveying them to the ball race. The counting out device was designed on the old-time "powder-flask" principle, and a long trough was employed to conduct the balls to the desired position. The complete device was built at a cost of about $25 or $30, and gave fairly satisfactory results when carefully operated.



Equipment used in assembling Balls in Ball Race

Several days after the assembler had been provided with the new device, it was noted that it had been discarded in preference to one of his own construction which consisted of a straight tube *A* and a bent tube *B* as shown in the illustration. The tube *A* served simply as a ball conveyor, the lower end being placed on the ball race as shown at *C*. The tube *B* is bent at a right angle at one end. The inner side of the bent portion was cut or filed away to make a trough of just the right length to hold nine balls when the outer end was slightly elevated.

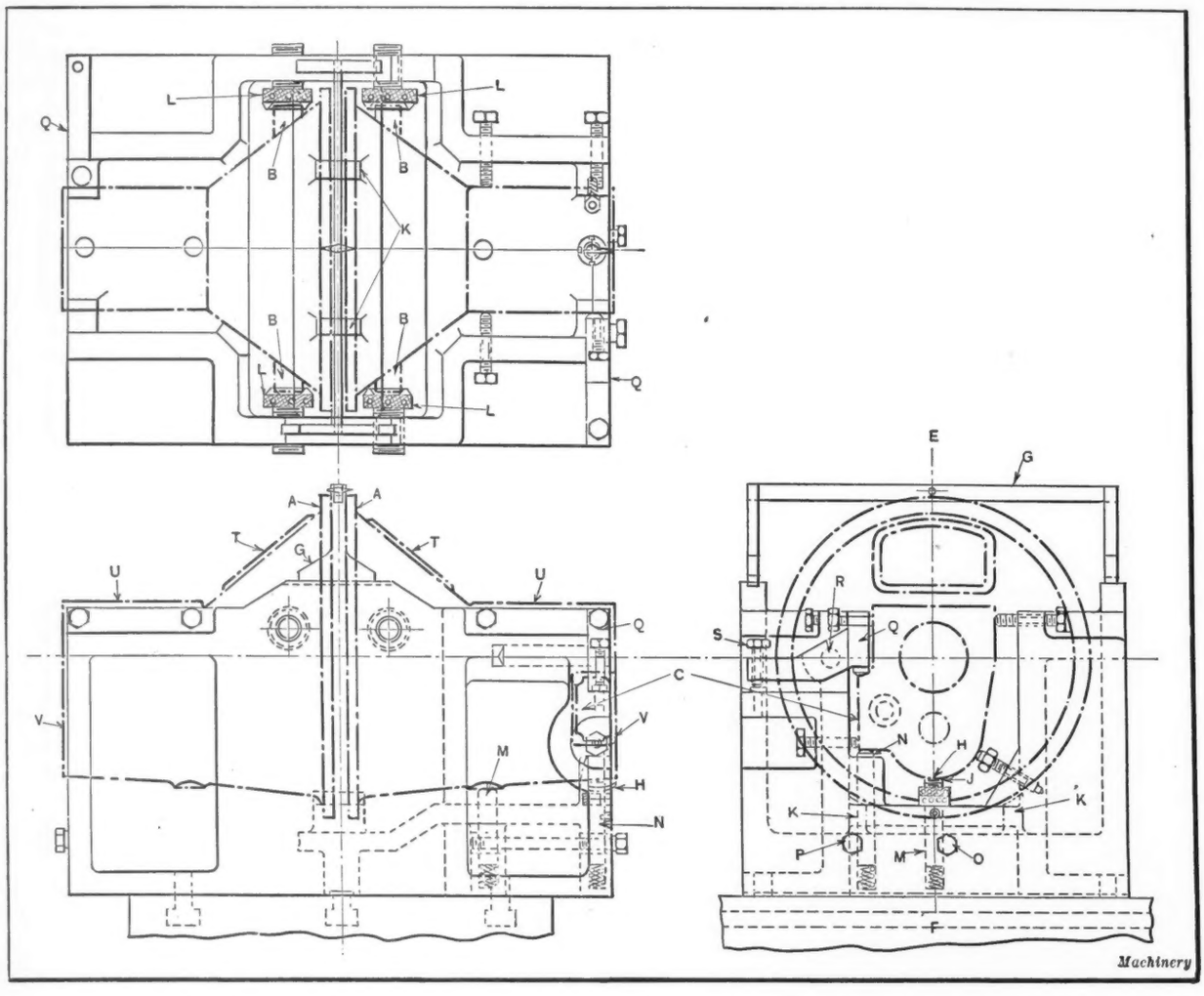
When employing this device 25 or 30 mechanisms were placed on a bench so that the ball races were in a horizontal position. Holding the tube *A* and a box of balls in the left hand, the assembler placed one end of

the tube *A* over the ball race and with his right hand dipped the bent end of tube *B* into the box of balls, and brought out the required number, emptying them into the upper end of tube *A*. This operation was repeated at each of the mechanisms until all the bearings were supplied with balls. This simple method of assembling proved accurate and rapid.

T. COVEY

TRANSMISSION CASE MILLING FIXTURE

The transmission case milling fixture shown in the accompanying illustration was designed to be used on an Ingersoll six-spindle slab milling machine. It holds two transmission cases *A* (shown by the dot-and-dash lines) while milling the three faces *T*, *U*, and *V* on each casting. The design embodies several unique ideas relative to the clamping, locating, and adjusting of the work. It will be seen from the illustration that the position of the faces to be milled and the odd shape of the work are such as to require a fixture of unusual design.



Milling Fixture for holding Two Transmission Cases while machining on a Six-spindle Slab Milling Machine

The flange end of the transmission case is round, with two bosses *B* cast on the sides, while at the opposite end is an air pump bracket boss *C*. It will be noted that most of the clamping is done at these two points. The transmission case first has a center line scribed on its face along line *EF*. This enables the operator to set the case in the fixture in a central position by means of a "bridge sighter" *G*, and the sighter *H* held in the end support *J*. After alignment, "sighter" *G* is removed from the fixture.

The work, when first placed in the fixture, rests on the stop-blocks *K* and the set rests *J*. In clamping the work, the cup-centers *L* are screwed out and the castings lifted up and adjusted to the correct position by using the "sighters" *G* and *H*. The stops *M* and *N* are then released by means of the screws *O* and *P*, so that they make contact with the work, after which they are locked in place. The clamp *Q* slides on the pivot-pin *R* and is actuated by screw *S*. The clamping action forces the pump bracket boss *C* against the stop *N*.

The sliding clamps *Q* enable the cases to be dropped directly into the fixture. After the cup-centers have been tightened on the bosses *B* and the clamps *Q* slid into place and clamped firmly, the other clamping screws are brought up tight so as to prevent chatter and take the thrust of the cutters. This fixture is of heavy construction, as it is designed for gang milling with heavy feeds. Accurate and speedy production is obtained with four of these fixtures set up on one machine.

Pittsburg, Pa. WILLIAM OWEN

STANDARDIZING CATALOGUE SIZES

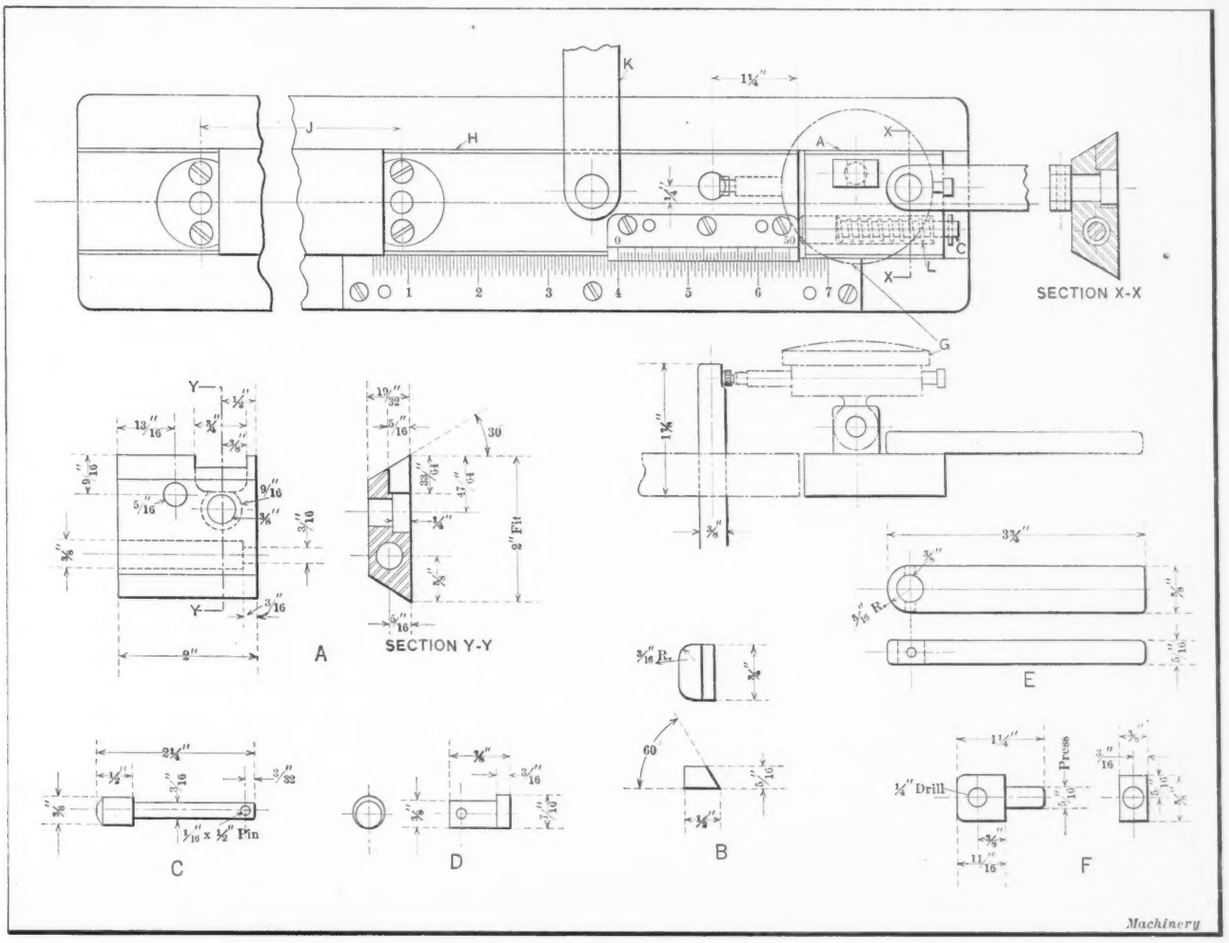
While great efforts are being made toward standardization in every field, very little has been accomplished along this line as regards the size of catalogues. A short time ago the writer attempted to arrange a few dozen catalogues which he keeps on his desk. In a total of seventy-two catalogues on seventeen different subjects, there were thirty-two distinct sizes, ranging from 3½ by 6 to 8½ by 11¼ inches. It seems possible that catalogues could be standardized to, say, three sizes, 8½ by 11, 5½ by 8½ and 4¼ by 5¼ inches. These sizes are all derived from the 8½- by 11-inch size, and would undoubtedly be found sufficient for all purposes.

Standardization of catalogues would not only make them handier for filing and reference, but it would also in time make catalogues cheaper. The various engineering and manufacturers' societies could render a great service by taking up this matter and pushing the adoption and use of standard sizes.

Cleveland, Ohio — EDWARD HELLER

PITCH LINE INDICATOR ATTACHMENT

Users of the Brown & Sharpe No. 0 gear-testing machine will find the pitch line indicator attachment here illustrated of great assistance in testing small gears. The details of the various parts of the attachment are shown so as to enable anyone who wishes to construct a device of this kind to do so readily without having to go to the expense of laying out the design.



Details of Pitch Line Indicator Attachment for testing Small Gears

The slide shown at *A* is machine steel and is fitted with a hardened tool-steel clamping gib *B*. The spring plunger *C* is cold-rolled steel, and the eccentric clamping stud *D* is hardened tool steel. The clamping lever *E* and the post *F* that supports the indicator are both made of machine steel. An Ames indicator shown by the dot-and-dash lines at *G* is used with the attachment. In using the attachment, slide *H* is first set to the required center distance *J* and locked by means of the lever *K*. The indicator slide *A* is then moved up until the indicator reads zero. Slide *A* is next locked in place. Plunger *C* is now pushed back, compressing spring *L*. Upon the release of slide *H* plunger *C* holds the master gear and the gear under inspection in contact at their pitch lines. By turning the gears, any eccentricity or unevenness in the rolling action is instantly shown by the indicator.

Eastwood, N. Y. — ELMER C. COOLEY

PERFORMANCE TEST QUESTIONS IN HIRING EMPLOYES

The so-called "trade test," under which an applicant for a job is asked a standard set of questions that are supposed to bring out his fitness for the job for which he is applying, has many advocates. A great deal can be said for this method, when applied in a practical and common sense manner; but it should not be forgotten that the trade ability of a worker is his ability, not to answer questions, but to step right in and do an average job in the line of work for which he is hired, without special instructions. He should be able to select and call for the necessary tools, appliances, and supplies for doing the work, and to set up the machine and make necessary adjustments, even though these may be slightly different from those to which he has been generally accustomed. Now, how is it possible to determine in conversation with the applicant whether he is able to do this, or not?

Mere oral tests by the foreman are insufficient, and may be misleading or unjust, or both. For instance, he may put a question that was actually asked in army trade test examinations: "When using top and bottom dies in making a forging, what is the waste material called, that forms around the workpiece?" One answer was "fin," which would have satisfied the writer, for example; but another was "flash"—an expression which the writer had never heard in that connection; still another was "scale," which he would have ruled out; while a fourth answer was "flange," which almost no one would have accepted. Yet all four terms were found to be correct and proper usage in different parts of the country.

A safer test would be, in the case of a power-hammer man, for example, to put him to work and say, "Run this

piece down to 1¾ inches on the Shaw hammer. If he did not at once ask, "Where is the gage?" (or "snap block," or even "peg") he could be turned down at once as not suited to be entrusted with a power hammer. Also, the man who on being given a performance test doesn't first look over the machine and appliances to see that they are ready to work properly, and next lay out all the work-pieces and the tools and supplies handily, so that no hunting will be required to find them when needed, might as well be laid off before being hired. The man who, upon being given a wrong or defective tool with which to do a certain piece of work, does not ask for something better, or at least look askance at it or raise his eyebrows in a deprecating manner, might as well not be taken on.

As a rule, trade ability is determined most quickly and safely by preliminary questions that would show the most thorough acquaintance with the work to be done, the way to do it, and the means to employ. The great difficulty with oral tests, as applied in large organizations by men who examine prospective employes, is, that the questions have to be such that they can be put by an intelligent examiner who has no specific knowledge of the trade. It is difficult for a man who himself is unfamiliar with the trade to conduct such an examination, but it has been suggested that in most manufacturing establishments the foreman can furnish the employment man with questions to which he can also supply every possible correct answer, so that the tests may be fair. The honesty of the applicant might sometimes be tested by asking him, not "Can you run a Lincoln milling machine?" because to this question he can answer "Yes" without any chance of being found out if he is not telling the truth; but by asking, "Can you run a Broynton milling machine?" If he answers "Yes," then the interview can be discontinued at once because there is no such milling machine.

New York City — ROBERT GRIMSHAW

MILLING CONNECTING-RODS

The connecting-rods used on the Reading-Standard motorcycle are of the solid and forked type common to the V-type engine. In the following is described a special machine used in milling the forked rod at the crankpin end. The solid rod works between the prongs produced by this milling operation. A front view of the machine with a rod set up to be milled is illustrated in Fig. 1. The rod is clamped on a driving plate *A* by means of a special clamp through which the cutter may be passed to bring it into position for feeding the work transversely. The faceplate or driver is then revolved, as required to sweep the rod around in milling the gap. The driving plate also carries a pin *B* against which the rod bears while it is being revolved by handwheel *C*. The cutter is ¾ inch wide and produces an opening of sufficient width to accommodate the solid rod.

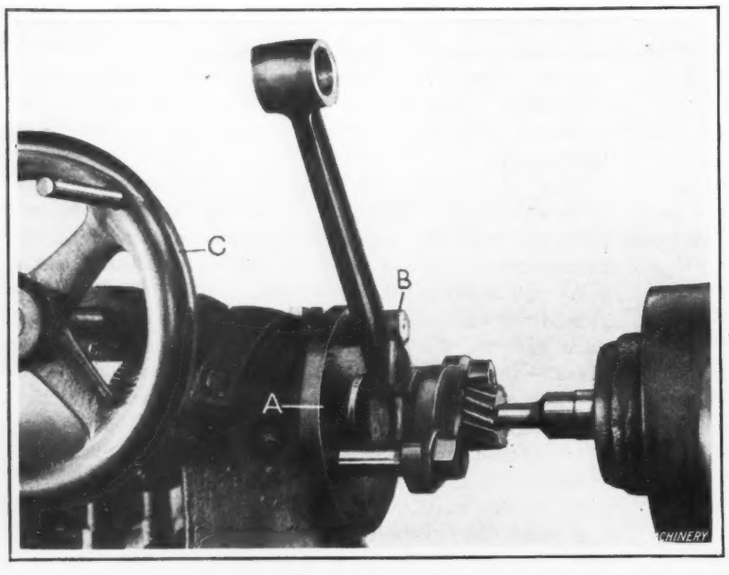


Fig. 1. Connecting-rod set up for milling Gap at Fork End

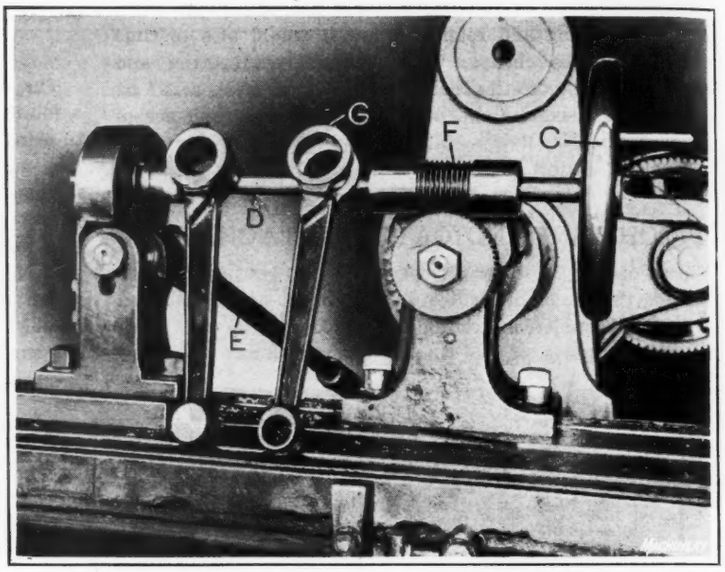


Fig. 2. End View of Machine, showing Hand Feed for Faceplate

The arrangement for revolving the faceplate is illustrated in Fig. 2. A worm-wheel on shaft *D* is driven by a worm through universal joints and shaft *E*. Worm *F*, which is also mounted on shaft *D*, drives a worm-wheel which is attached to the shaft on which the faceplate is carried. As the connecting-rod is revolved by handwheel *C* it is fed slowly past the revolving cutter. During this operation the entire amount of metal is not removed, there being a narrow tie-bar left at *G* to prevent the rod from springing out of shape while being milled. This connection is of course subsequently removed.

Providence, R. I. — ROBERT MAWSON

* * *

AIR-DRIED AND KILN-DRIED WOOD

It is sometimes claimed that kiln-dried wood is not as strong as wood that has been air-dried. Others again have advanced figures indicating that kiln-dried wood is much stronger than air-dried. In order to settle this question, the forest products laboratory of the United States Forest Service at Madison, Wis., made some 150,000 comparative strength tests on specimens from twenty-eight different common species of wood. The results of these experiments showed conclusively that good kiln-drying and good air-drying have the same effect upon the strength of wood.

The belief that kiln-drying produces stronger wood than air-drying is usually the result of failure to consider differences in moisture content. The moisture content of wood on leaving the kiln is usually from 2 to 6 per cent lower than that of thoroughly air-dried stock. Since wood increases in strength with loss of moisture, higher strength values may be obtained from kiln-dried than from air-dried wood; but this difference in strength has no practical significance, since in use a piece of wood will come to approximately the same moisture condition whether it is kiln-dried or air-dried.

Questions and Answers on Practical Subjects

PROPORTIONING CONE PULLEY STEPS TO GIVE CONSTANT BELT TENSION

L. M. H.—Please show how to calculate the diameters of the unknown steps on the larger of a pair of cone pulleys so that the tension on an open belt will be the same on all steps. The diameters of the steps of the smaller pulley are 3, 4, 5, and 6 inches, respectively, and the largest step of the large pulley is 8 inches in diameter. The distance between the shaft centers is 18 inches.

ANSWERED BY W. W. JOHNSON, CLEVELAND, OHIO

The accompanying illustration shows diagrammatically at *A* the conditions of the problem, dimensions *X*, *Y* and *Z* being unknown. The length of belt required to pass over

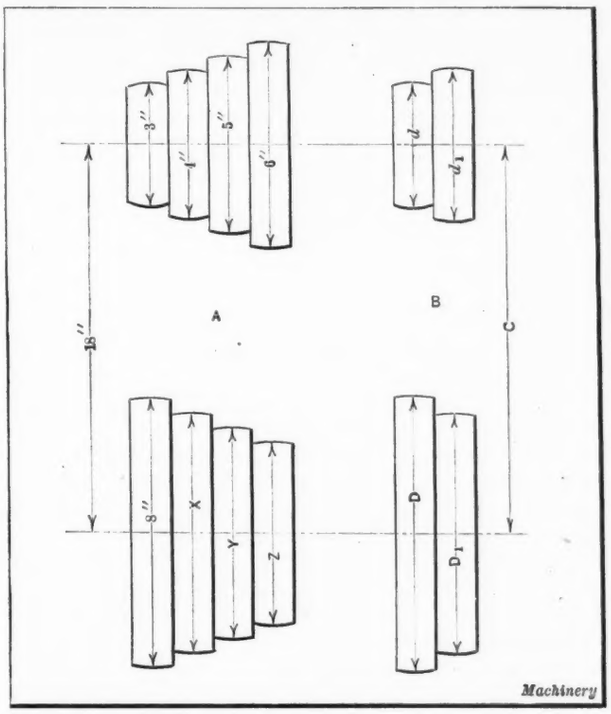


Illustration showing Conditions of Problem on Cone-pulley Design

two pulleys is obtainable by a formula given in MACHINERY'S HANDBOOK on page 722 which is as follows:

$$L = 2C + \frac{11D + 11d}{7} + \frac{(D-d)^2}{4C} \qquad (1)$$

in which

L = length of belt;
D = diameter of large step;
d = diameter of small step; and
C = center distance between pulleys.

By substituting $\frac{\pi}{2}$ for $\frac{11}{7}$, this formula may be written as follows:

$$L = 2C + \frac{\pi}{2} \times (D + d) + \frac{(D-d)^2}{4C} \qquad (2)$$

From this a formula can be derived for finding the diameter of any unknown step on either pulley that will cause the belt tension to be the same on any pair of steps. This is, of course, due to the fact that the proper belt length for any pair of steps will be constant. In the following formulas, L and C equal the same values as before, and

D = largest step on larger pulley;
d = smallest step on smaller pulley;
D_1 = any step on larger pulley; and
d_1 = corresponding step on smaller pulley.

Then, from Formula (1) and *B* in the illustration,

$$L = 2C + \frac{\pi}{2}(D_1 + d_1) + \frac{(D_1 - d_1)^2}{4C}$$

Equating this with Formula (2)

$$2C + \frac{\pi}{2}(D + d) + \frac{(D-d)^2}{4C} = 2C + \frac{\pi}{2}(D_1 + d_1) + \frac{(D_1 - d_1)^2}{4C}$$

Arranging according to powers of $D_1 - d_1$,

$$(D_1 - d_1)^2 + 2\pi C\,(D_1 - d_1) + 4C\left[\pi d_1 - \frac{\pi}{2}(D + d)\right] - (D - d)^2 = 0$$

Solving this quadratic equation for $D_1 - d_1$ and taking the plus sign before the radical,

$$D_1 - d_1 = \sqrt{(\pi C + D + d)^2 - 4\,(\pi C d_1 + Dd)} - \pi C \qquad (3)$$

From this formula D_1 or d_1 can be found when either one is known. Substituting the known values,

$$D_1 = \sqrt{(18\pi + 8 + 3)^2 - 4\,(18\pi d_1 + 8 \times 3)} - (18\pi - d_1)$$
$$= \sqrt{4562.8404 - 226.1952\,d_1} - 96 - (56.5488 - d_1)$$
$$= \sqrt{4466.8404 - 226.1952\,d_1} - (56.5488 - d_1)$$

Now solving for diameter *X* in the illustration, in which case $d_1 = 4$ inches,

$$X = \sqrt{4466.8404 - 226.1952 \times 4} - (56.5488 - 4)$$
$$= \sqrt{3562.0596} - 52.5488$$
$$= 59.683 - 52.549 = 7.134 \text{ or } 7\tfrac{1}{8} \text{ inches}$$

Solving for *Y* in which case $d_1 = 5$ inches,

$$Y = \sqrt{4466.8404 - 226.1952 \times 5} - (56.5448 - 5)$$
$$= \sqrt{3335.8644} - 51.5448$$
$$= 57.757 - 51.549 = 6.208 \text{ or } 6\ 13/64 \text{ inches.}$$

Finally, solving for *Z*, in which case $d_1 = 6$ inches,

$$Z = \sqrt{4466.8404 - 226.1952 \times 6} - (56.5488 - 6)$$
$$= \sqrt{3109.6692} - 50.5488$$
$$= 55.764 - 50.549 = 5.215 \text{ or } 5\ 7/32 \text{ inches.}$$

TRANSMISSION FOR MOTOR DRIVE

E. B. M.—When a machine is to be motor-driven, what is generally considered the most satisfactory and efficient method of transmitting motion from the motor to the machine? Is it preferable to use a belt, chain, or gear drive?

A.—The best and most efficient drive depends upon conditions subject to wide variation. Thus belting, chain drives, gearing, and the direct drive are all satisfactory under different conditions. The distance between the driving and driven shafts, the speed ratio and the importance of having a compact drive or self-contained machine are factors to be considered.

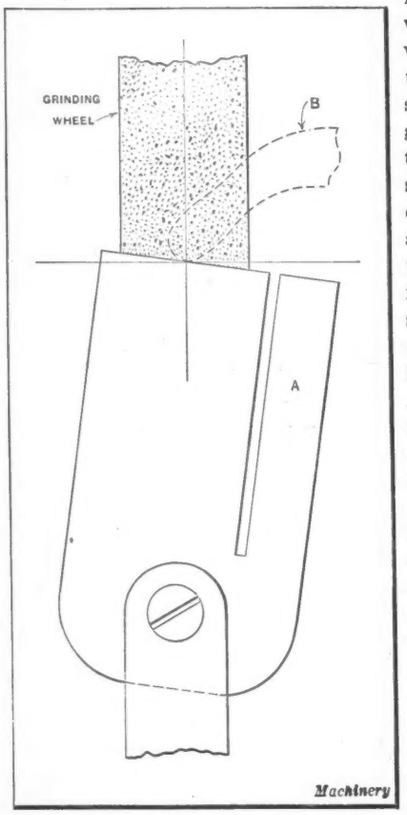
Ordinarily, leather or other belting is used for the longer center distances; some type of chain drive is used when the center distance is too short for belting and too long for gearing; and gearing is used when the motor can be placed quite close to the driven shaft, except on machines which can have the motor connected directly with the driven shaft as, for example, machines not requiring a reduction of speed between the motor and the driven shaft. Sometimes belts have been applied to motor drives where the center distance

was rather short and the speed ratio high, so that there was insufficient arc of contact, and in order to prevent excessive slipping, either an idler pulley is used to increase the arc of contact or the belt is tightened excessively. Such a drive is detrimental both to the belt and also to the bearings, and a positive drive, such as a silent chain, is much more efficient in such cases because slippage is prevented and there is no initial pressure on the bearings.

GRINDING SPIRAL MILLING CUTTERS

F. E. S.—In grinding the teeth of spiral milling cutters, should the upper edge of the finger that supports the cutter conform to the angle or inclination of the tooth being ground, and where should this supporting finger be attached?

A.—In grinding a spiral milling cutter the tooth-rest should remain in a fixed position relative to the wheel, and it should be somewhat wider than the wheel face so that the cutter will be supported before the grinding begins. The top of the tooth-rest should preferably incline so that it has an even bearing on the tooth. A good form of tooth-rest is shown in the accompanying illustration. It has a flexible part *A*, which permits indexing the cutter from one tooth to the next by simply springing this flexible part and without removing the cutter from the tooth-rest. When setting the tooth-rest a height gage, which conforms to the height of the wheel center, should be located so that the end is opposite the center of the wheel face, the end of the gage being indicated by the dotted lines *B*. The tooth-rest is then adjusted until it is contact with the gage and at the tooth angle. After this has been done there is a vertical adjustment between the wheel and the cutter, the amount depending upon the desired clearance angle.



Tooth-rest for Use in grinding Spiral Milling Cutters

PLASTER MOLDS

Can plaster molds such as described in June MACHINERY in the article "Plaster Molds for Small Castings" be used for more than one pouring? If new molds have to be made for each heat does not the cost of plaster molds become high as compared with sand molds? Would plaster molds be economical for quantity work?

ANSWERED BY FRANK LUX, NEW YORK CITY

Plaster molds cannot be used for more than one pouring. Their cost is higher than sand molds, but the results obtained are far superior, and their use is recommended where a good finish is required. In appearance, the product made resembles a die-casting, and fine detail can be brought out clearly. Tablets, medals, and nameplates have been made by the writer, but this process is useful for many other products as well. Automobile hardware with ornamental design has been produced in this way on a production basis. Generally speaking, this method of producing castings is for a special class of work. In some cases it is cheaper than sand-molding, as machining operations can be eliminated on such parts as small gears which do not require close limits. These parts have been made to limits of plus or minus 0.003 inch.

DETERMINING LENGTH OF ROLLED BELT

A. F. S.—What is the rule for finding the length of a belt or tape when rolled up, assuming that the outside diameter, diameter of hole, and the number of coils are given?

A.—The length, in feet, of a closely-rolled belt may be determined by the following rule: Find the sum of the outside diameter and the diameter of the hole in inches. Multiply this sum by the constant 0.1309, and the result by the number of complete turns of the belt. The rule is based on the rule for obtaining the length of a plane spiral. In order to obtain the length of the spiral, the sum of the inner and outer diameters is divided by 2, and the quotient is multiplied by 3.1416. The product is again multiplied by the number of turns made by the spiral. In the application of this rule, if the inner and outer diameters are in inches, the length of the spiral will also be in inches. If instead of dividing by 2 and multiplying by 3.1416, the sum of the inner and outer diameters is multiplied by the constant, 0.1309, as previously mentioned, the result will be obtained in feet, since $3.1416 \div 2 \times 12 = 0.1309$.

HORSEPOWER AND TORQUE

S. J.—What is the meaning of "torque," and how is the relation between torque and horsepower determined?

A.—When applying power by rotation, the pull required on a pulley varies inversely as the radius at which the pull is applied, and when power is expressed as "torque" it generally means the pull required at 1 foot radius. Thus the torque of a motor is its turning moment or the number of pounds of effort exerted at a radius of 1 foot.

To find the horsepower that is equivalent to a given torque and speed of rotation, the following formula may be used, in which

H = horsepower;
T = torque at 1 foot radius; and
R = revolutions per minute.

$$H = \frac{T \times R \times 2 \times 3.1416}{33\,000} = \frac{T \times R}{5252} \qquad T = \frac{H \times 5252}{R}$$

TANKS FOR STORING FUEL OIL

L. S.—What precautions are necessary in the construction of monolithic cement tanks for the storage of fuel oil in order to prevent the oil from penetrating through the walls?

A.—It is not necessary to use waterproofing material for the walls if the viscosity of the oil is high, because thick oil, after it has penetrated through two or three inches, will fill the pores and offer an excellent resistance to further penetration. For this reason the walls of the tanks should be comparatively thick, say 8 or 10 inches, depending upon the capacity of the tank.

For light oils, such as gasoline, which are very penetrative and which do not possess the sealing quality of the heavier oils, the porous walls of the tank must be sealed. For this purpose, a ½-inch coating of plaster should be used This plaster may be made from equal parts of cement and fine sand, mixed with a waterproofing compound. The coating should itself be treated to a solution of silicate of soda applied with a brush.

The British Metal-working Industries

From MACHINERY'S Special Correspondent

London, September 14

TANGIBLE evidence of improvement in several of the metal-working trades is accumulating and is particularly noticeable in the textile, engineering, automobile, and railway shops. As far as the machine tool industry is concerned, the limited demand has been met for many months by second-hand machines and the abundant stocks of new machines that were accumulated at the beginning of the slack period. A big business is still going on in second-hand machine tools. The increasing sales of new machines by well-known makers is a welcome sign. One of the best known makers of turret and capstan lathes sold sixty machines during last month, the most popular size being 16-inch swing; another well-known maker reports similar business. Heavy and medium capacity machine tools for the electrical trade are in good demand, and there is a demand for machine tools for machining turbine castings, and equipment for cutting turbine reduction gears. Special machine tools designed for the reduction of manufacturing costs are also being bought.

A very satisfactory feature in the present position of the machine tool industry is the growing demand from abroad. France, in particular, is a steady buyer and has taken a large number of the reconditioned machine tools. Dealers in France are able to import machine tools from this country and sell them at much below the price quoted for similar machines offered by continental dealers. Colonial railways are resuming buying, and India and South America are prominent among the prospective buyers.

The small tool industry continues to improve, and in the Sheffield district large Russian orders have recently been shipped to Siberia; the tools include cross-cut saws, hand saws, files, threading equipment, and various types of edged tools. The order was received through an agency in London on behalf of the Soviet Government, the suppliers receiving cash on acceptance of the order. The total value of the order is supposed to be in the neighborhood of £200,000.

Textile machinery makers have been particularly busy, and the demand is becoming more and more insistent from all parts of the world. Platt Bros. & Co., Ltd., Manchester, one of the largest textile engineering firms in the world, have orders in hand to the value of over £8,000,000, and another well-known firm of textile engineers, Dobson & Barlow, Ltd., have orders to the value of £3,000,000. A fair proportion of these orders are from China for the equipment of new cotton mills in that country which are being erected by Japanese capitalists. The first-mentioned firm has supplied in all something like 80 per cent of the cotton machinery used in Japan. The recent undertaking of the Japanese at the Washington Conference to abolish night work in their mills has caused the Japanese to increase greatly their textile equipment in existing works, so that their gross output shall not be reduced by the reduction in the working hours.

The Automobile Industry

The automobile industry continues to show a great deal of activity. As has been mentioned in previous letters, the small car is attracting many of the well-known manufacturers, who up to now have concentrated on more elaborate vehicles. Several of these makers are endeavoring to market a small car capable of carrying two, or at the most three people, at about £200. Several of these cars will be shown at the forthcoming Olympia show in November.

There has been much comment in the past on the extent to which America has captured the trade in light automobiles in several of the British Colonies, and it has frequently been said that it is due to want of foresight on the part of the English manufacturer in meeting the special needs of the Colonies. It has been pointed out, however, that the conditions in America are very similar to those in many of the Colonies and the normal home demand in America has therefore brought forward a type of car that is eminently suitable for a wide overseas market. The accuracy of this line of thought is shown in the fact that America's high-grade cars are practically unknown in the Colonies, whereas many makes of the better grade of English cars find their way into these markets.

Overseas Trade in Machine Tools

During July the exports of machine tools corresponded very closely with that of June, the total value of the exports being £75,549. Imports, however, showed a sharp rise, the total value amounting to £43,706. The value per ton of exports was £140, and that of imports £121. Drilling machines, lathes, planing and shaping machines, presses, and miscellaneous machine tools not coming under any general classification were most prominent in the export figures, whereas lathes and milling machines were large items in the import returns. It is interesting to note that during July 109 lathes were exported and 91 imported.

It was thought at one time that Germany would rapidly build up a trade in machine tools in this country, and until March of this year the returns appeared to lend weight to this view; in fact, attempts were made to have machine tools placed on the list of imports coming under the Safeguarding of Industries Act. Since that date, however, the imports of German machine tools into this country have shown a distinct falling off, and both in value and weight the figures now correspond with those of October last year. At the highest point, however, the tonnage import was only 209 per month, the value being £13 500. In June the tonnage was only 85, and the value £6500.

Before the war Germany had the monopoly of the manufacture of tungsten and was England's best overseas customer for high-speed steel. Germany, however, developed her steel production to such an extent during the war that she is now able to manufacture practically all of her own requirements in high-speed steels. She has now become a large buyer of tungsten and her steel-makers are buying more of this material than was previously sent to all of the British steel makers.

New Machines and Developments

Mention was made in a previous letter of a 120-foot bed lathe recently sent to Japan by Thos. Shanks & Co., Johnstone. Some very stringent requirements had to be met, and an accuracy of plus or minus 0.002 inch was required, regardless of the weight of work on the faceplate or between centers. As the machine was constructed to carry work weighing up to 100 tons, the exacting nature of this specification can be realized. Another very large machine tool sent to Japan is for installation in the naval shops at Tokio; it is for grinding armored plate and weighs 60 tons. The grinding wheel weighs 2 tons and is 54 inches in diameter, and the machine requires 120 horsepower for driving; the makers are Taskers Engineering Co., Ltd., Sheffield.

Nut-tapping Machine of Belgian Design

By A. L. VALENTINE*

A NEW principle in tapping machine design is shown in Fig. 1. The tap, instead of being held in a chuck in the usual manner is supported and driven by hollow spindles located on each side of the work. The spindles do not advance, but drive or rotate the tap in such a manner that it is permitted to feed itself through the work. A lead-screw is employed in starting the tap, but is disengaged as soon as the tap has entered the work far enough to become self-feeding. Thus any errors that might result from a difference between the lead of the tap and that of the lead-screw are avoided. The work remains in a fixed position near to and between the ends of the hollow spindles during the tapping operation.

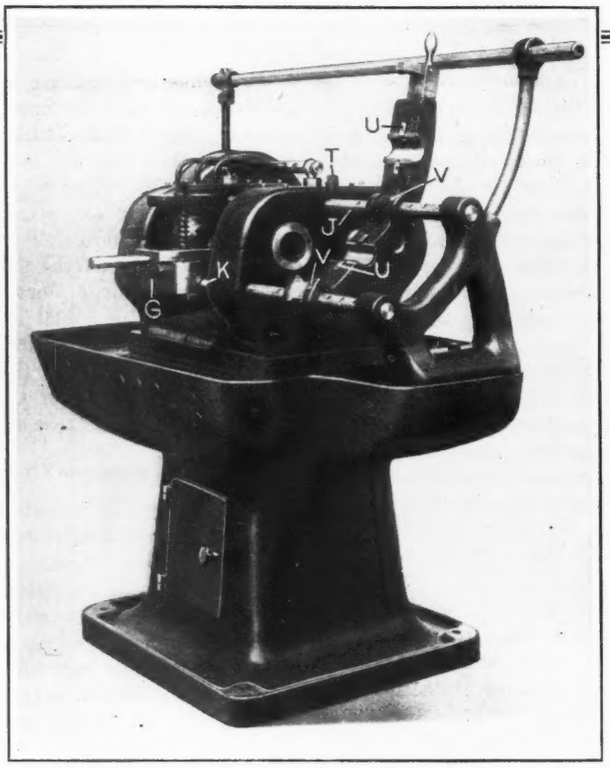


Fig. 1. Machine designed for tapping Deep Threads of Coarse Pitch

Referring to Fig. 2, at *A* and *B* may be seen the noses of the hollow spindles that support and drive the tap *C*. The tap becomes self-feeding after being started in the work *E* by the lead-screw *D*. In this case the work is held in a special fixture *F*, shown in Figs. 3 and 4. The work *E*, Fig. 3, is a steel casting about 6 inches long, with an opening in the center approximately 2 inches in length. The tapped hole is about 1⅞ inches in diameter, and the pitch approximately 5/16 inch. The time required for tapping this piece is ninety seconds. As further examples of the production rates obtained on this machine, it may be mentioned that the time required in tapping a nut of steel 4 inches long with a continuous thread of ¼ inch pitch, and a diameter of 2⅛ inches, was eighty-five seconds, and the tapping time for a nut of steel 2½ inches long with a continuous thread 1⅝ inches in diameter, and ¼ inch pitch, forty-five seconds.

Referring to Fig. 4, it will be noted that work *E* fits loosely in the pocket of the fixture, and that there is considerable clearance between the work and the retaining latch *H*. The method of mounting the fixture on the bars *J* and *K*, Fig. 2, permits a limited crosswise movement. Thus the work is permitted to float a sufficient amount to allow the drilled hole to be aligned properly by the pilot section of the tap. The tap enters the work through the spindle nose *B* and after passing completely through, is removed from the spindle on which nose *A* is mounted.

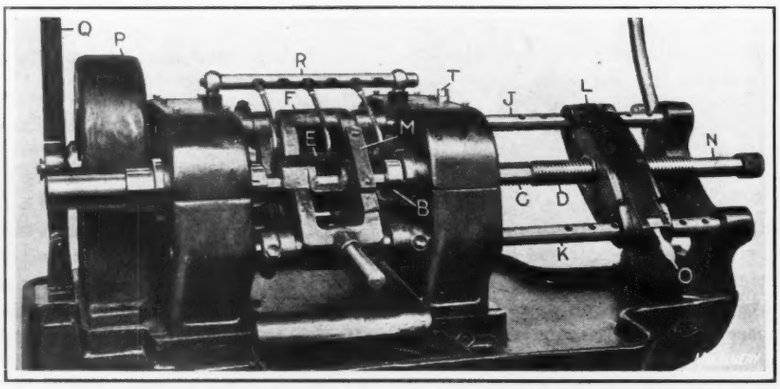


Fig. 2. Tapping Machine equipped with Special Work-holding Fixture shown in Figs. 3 and 4

Design of the Tap Used

The design of the tap used with the machine here described is shown diagrammatically in the upper view of Fig. 5. The enlarged sectional view in the lower left-hand corner shows the method of driving the tap. The three deep grooves or flutes which extend the entire length of the tap are engaged by the two driving noses of the spindles, as indicated. Driving noses having openings of the correct size and shape to accommodate taps of different sizes can be readily and quickly attached to the spindles in place of those shown at *A* and *B*, Fig. 2. Lead-screws and lead-screw nuts of the same pitch and lead as the taps are supplied.

Referring to the upper view, Fig. 5, section *A* of the tap serves as a combination pilot and reamer. This section passes through the work and enters the driving nose *A*, Fig. 2, before the tapered and threaded part *B* of the tap enters the work or before the tap actually begins to cut. The full-thread part *C* of the tap brings the thread to the exact size and form. The squared end at *D* fits into a square hole in the end of the lead-screw *D*, Fig. 2, which controls the feeding movement until the tap is well started in the work, at which time the tap is disengaged from the lead-screw in a manner to be described later.

Operation of the Machine

The actual operation of the machine is very simple. The operator drops the work into the fixture *E*, Fig. 2, swings the latch *M* into place, inserts the reamer in the work as far as it will go, and places the lead-screw *D* in the position shown, after which he starts the machine. The spindles are driven from the same shaft, and exert an equal driving force on the tap. As the tap is connected with the lead-screw *D*, the lead-screw feeds it inward until the unthreaded part at *N* rests in the split nut mounted in

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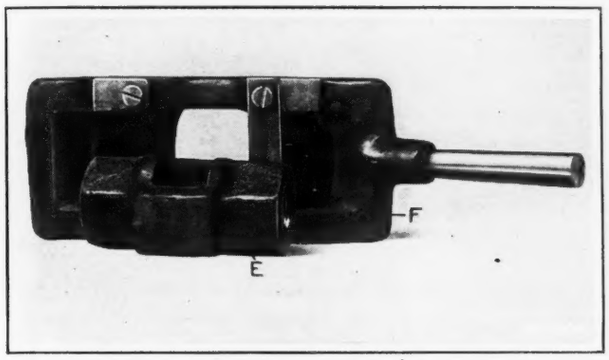

Fig. 3. Tapping Fixture with Work removed

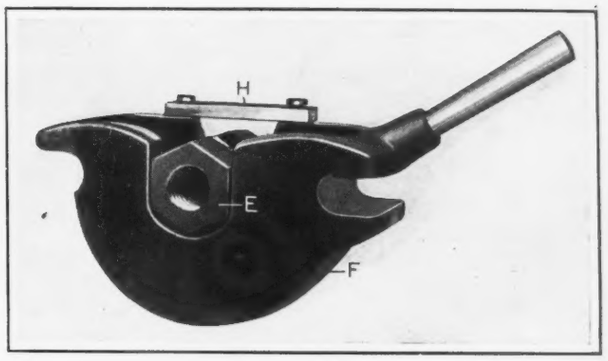

Fig. 4. Fixture with Work in Place

the holder *L*. At this point the tap becomes self-feeding. When the tap has passed completely through the work, it is removed from spindle *A* by the operator. The work is then removed and replaced by a new piece. The split-nut holder *L* is next unlatched by a movement of lever *O*. The upper half of the holder is swung upward so that the lead-screw *D* can be removed to permit the tap *C* to be inserted. The lead-screw is then returned to the position shown in Fig. 2, and the holder *L* closed and locked, after which the tapping operation is repeated.

The regular machine is belt-driven, but can be easily arranged for motor drive. The driven pulley is enclosed by guard *P*, Fig. 2, and is engaged with the pinion shaft, which drives the spindles by means of a clutch operated by lever *Q*. An idler pulley provided with a belt-tension adjusting device is secured to the left side of the machine base. A gear-driven pump located in a reservoir in the base feeds the cutting compound to the work through the bent pipes leading from tube *R*. The work-holding fixture shown at *G*, Fig. 1, is the type regularly supplied with the tapping machine. A transverse adjustment of the holding clamp is permitted by the gibbed slide, and a vertical adjustment of the clamp can be effected by pivoting the fixture on the bar *K*.

The split-nut holder *L*, Fig. 2, is held in place on bars *J* and *K* by screws *V*, Fig. 1. This permits the holder to be located in whatever position is best adapted for the work being done, or, in other words, so that the tap can disengage itself from the lead-screw when it is once properly started. By locating the holder *L* farther to the left, the lead-screw will remain engaged with the tap for a longer period. A finer adjustment of the point of disengagement of the lead-screw is obtained by the pinion stud *T*, which meshes with rack teeth cut in bar *J*. Bar *J*, with holder *L* attached, can thus be moved in or out by adjusting stud *T*. The two halves of the split nut are held in place by small clamps *U*, Fig. 1, and can be readily changed to accommodate the lead-screw that is used.

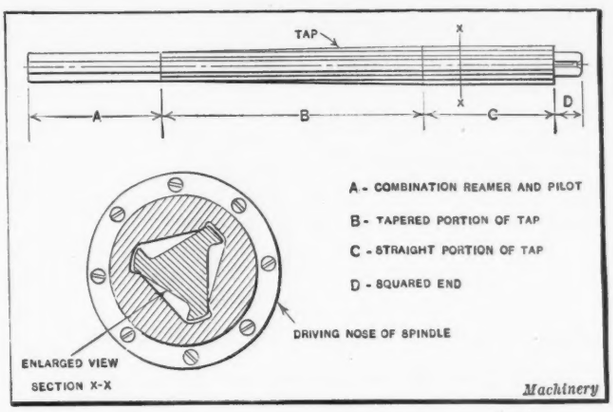

Fig. 5. Diagram showing Tap and Driving Nose of Spindle

The tapping machine shown in Fig. 1, which is a product of the firm of Le Progres Industriel, Loth, pres Bruxelles, Belgium, has a capacity of 2 inches; a smaller machine of similar design having a capacity of 1 inch is also made by the same company. These machines are designed primarily for tapping deep threads of coarse pitch, particularly those of the Acme, square, and similar forms.

A great variety of irregular-shaped pieces can be handled by the tapping machines described. Pieces of unusual shape often require special fixtures, as in the case of the part shown at *A* in Fig. 6. The fixture *B*, with the work and tap in position, ready for the tapping operation, is shown in Fig. 7. The work in this case is allowed a certain amount of float, being brought into alignment by the pilot of the tap. It will be noted from the illustration, however, that the fixture is designed to hold the work in such a manner that the trunnions projecting from its sides will be at right angles with the tapping spindle.

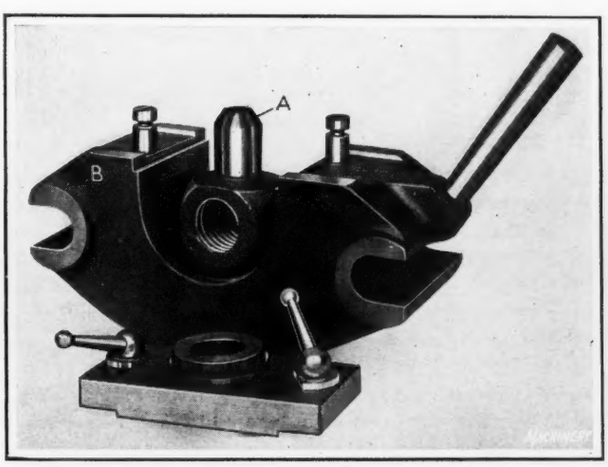

Fig. 6. Special Work-holding Fixture with Clamp removed

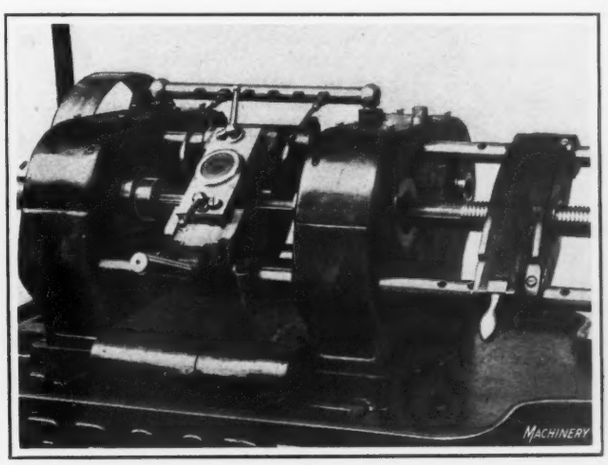

Fig. 7. Tapping Machine equipped with Fixture shown in Fig. 6

Production Rates

The high production rates obtained with this machine are due chiefly to the method of driving the tap. As will be evident from the preceding description, taps of unusual length may be employed, when necessary. This permits a thread to be cut with only one tap, in many instances where the depth of thread required would necessitate the use of two or more taps of the usual type. It may be mentioned here that the breakage of taps in this machine is almost an unknown occurrence. By driving the tap from both ends and adjusting the spindles so that the driving noses are close to the work, the torque or stress imposed on the tap is reduced to a minimum. This permits running the taps at exceptionally high speeds, which, of course, results in a high rate of production.

* * *

GREAT TELESCOPE BUILT BY WARNER & SWASEY CO.

One of the largest telescopes in the world—a sixty-inch reflector—has just been completed at the plant of the Warner & Swasey Co., Cleveland, Ohio, for the Argentine National Observatory. This telescope will be the largest in the southern hemisphere, and there are only two telescopes in the world which exceed it in size.

The tube of the telescope is built in three sections—the cast-iron mirror cell, which contains the mirror; the centerpiece casting, which is fastened to the declination trunnions; and the tube proper. The latter is made up of structural steel members, and is 6 feet in diameter and 17 feet long. Its weight is 2400 pounds. Two forged steel trunnions, running in double thrust and radial ball bearings support the tube. The trunnions are, in turn, supported on a large fork mounted on the end of the long forged-steel polar axis. The polar axis is a hollow steel forging with a large flange and taper nose at its upper end to which the fork is attached. It is 15 feet long and 20 inches in diameter at its upper end.

The circles and gears for setting and rotating the telescope in right ascension are found at the lower end of the polar axis. Directly beneath the gears is the gear-box and mechanism for sidereal drive. The final drive in this mechanism is obtained through an accurate worm and worm-gear, the latter being 9 feet in diameter. The teeth of this worm-gear are very accurately spaced from a master circle divided on the Warner & Swasey automatic dividing engine. The worm-gear is operated by a gear-box mounted directly underneath, the gears of which were cut on a special machine accurate to one two-hundred-and-sixty-thousandth part of a circle. This machine, in turn, is dependent for its reliability on the 40-inch dividing engine previously mentioned, which is exact to nearly a three-millionth part of a circle—the most precise dividing engine in the world.

The main or parabolic mirror is 61 inches in diameter and 8½ inches thick at the center. It weighs about 2100 pounds. The focal length of the mirror is 25 feet, forming an image of any celestial object at the upper end of the tube. At the upper end an adapter is attached for holding photographic or spectrographic apparatus to receive this image. This telescope is to be used for photographic and spectroscopic study of the stars, rather than for visual observations. The new instrument will be able to detect some 150,000,000 distinct bodies, compared with the bare 5000 within the range of the unaided eye. The camera attached to a telescope of equal size showed in a photographic plate 50,000 stars in a part of the sky occupying about as much space as the full moon.

Among other great telescopes designed and constructed by the Warner & Swasey Co. are the 40-inch Yerkes, 36-inch Lick, and 26-inch United States naval refractors, and the 72-inch Canadian and 36-inch Arizona reflectors.

BUYING TOOL STEEL ON ANALYSIS

In recent years several of the large companies using tool steel have prepared specification analyses of tool steels and are buying steel according to these analyses. It is quite generally agreed, however, that tool steel cannot be classified or standardized by analysis. This subject was dealt with in a thorough manner in an address made by Roy H. Davis, general manager of the Firth Sterling Steel Co., before the National Association of Purchasing Agents. He pointed out that metallurgists, chemists, and heat-treaters are as yet unable to identify definitely the virtues or characteristics that make one bar superior in quality to another bar which is of apparently the same composition. In view of this, it is safer to buy tool steels by brands rather than by specifications.

Contrary to the general impression, there is nothing mysterious or secret about the chemical contents of a bar of steel. The analysis is free to the public, and the manufacturer will gladly give full details. Under the "specification" policy, the steel maker finds little difficulty or complication in melting tool steel to a special analysis, provided he is willing to sacrifice quality. He has complete control over the steps in melting. Melting is the only operation that influences analysis; but, in addition to melting, each subsequent step in manufacture has its influence on the quality. If the specification calls for a steel of unusual chemical composition the melter will add or subtract certain elements to or from the mix; or he will so manipulate the slags as to create reactions that will help him to the result specified.

Under the "brand" policy, the custom has been established of holding the maker of the steel wholly responsible for its quality and suitability. Should the steel fail, when it is properly treated, and the tools or dies are properly designed and used, the custom has been to require the maker to replace the steel without charge. If this old established practice be abandoned, and the analysis policy substituted (either by individual steel companies or by the steel trade generally), there would necessarily follow a decided shrinkage in the steel maker's responsibility and a decided increase in the buyer's responsibility regarding the quality and suitability of the finished steel. It is therefore safer to buy on the "brand" policy, because brands represent a measure of quality, a standard, and a character established over a long period of years.

Tool steel may be purchased on an analysis basis with one of two objects: First, the specification may be broad and one easily met as regards analysis. In this case a low price will be the object. Price competition in place of quality competition will result. As a consequence a low price and a low quality will be obtained, because to meet the price the manufacturer will use the cheapest raw materials and the cheapest melting and manufacturing methods that will produce steel within the specification. Cutting and wearing quality will be sacrificed, since analysis and price will be the standards of measurement.

In the second case the specification may be drawn along narrower lines with the object of obtaining more uniformity and better quality. In order to meet the narrow limits, the steel manufacturer may use extraordinary methods in melting that will not help the quality, but that will probably be a detriment; and there will also be losses in manufacture, increasing the cost. The increased cost will not be the result of his effort for quality, but of his effort to meet the narrow specification.

It is therefore not advisable to purchase tool steel on a price consideration or to an analysis specification. What should be purchased is steel-making ability. The success of the steel maker's brand in the customer's shop is as vital and necessary to him as the customer's success in his own business.

German Industrial Conditions

From MACHINERY'S Special Correspondent

Berlin, September 7

THE entire German industry, including the machine tool industry, has shown a high rate of activity during the summer months, in spite of the lack of coal and raw materials, increased prices, and many other difficulties. The low value of the mark has made it impossible for a large number of the population to buy even necessities, and has forced them to restrict their consumption entirely to the home market. There has, however, been practically no unemployment, the general activity in the industrial field being such that there is a lack of skilled workers in all trades. In the middle of the summer only 0.6 per cent of all the members of the trade unions were reported as out of employment, and in one instance a record was taken of 100 positions to be filled, for which the total number of applicants was only 103. Nevertheless, all the industries are not working at their full capacity, because of the scarcity of coal and raw materials. Twenty blast furnaces are shut down on this account, and English coal and pig iron is being bought.

The Machine Tool Industry

Reports from the machine tool industry are contradictory. In some cases one hears complaints of the decline of foreign orders and statements to the effect that the time has come when it is no longer possible to compete in foreign markets. On the other hand some manufacturers report many orders on hand and a great number of new orders coming in. The greatest difficulty is probably to be found in the fact that the domestic buying power of the mark is rapidly decreasing. The buying power of the mark in the home market has always been much greater than in foreign markets, and this has made the conditions within Germany more tolerable. The favorable conditions in industry during the past year have been largely due to the difference between the domestic and foreign buying power of the mark, which meant that production costs were low, while selling costs were based more nearly upon the world's market conditions. Now this difference is less noticeable and the prices in the home markets are rapidly increasing, so that they approach those in the world's markets. As soon as an equilibrium is reached in this respect, it would appear that a great economic crisis must take place in Germany, and the social consequences of this are feared by many. The dropping of the mark to the point where it is practically in the same class as the Austrian crown, is a very serious condition.

Prices and Terms of Payment in the Machine Tool Industry

There has been no such thing as stable prices in the machine tool industry during the past year. Last fall a sliding scale was established, two methods being adopted for determining the variations in the scale. One method was determined upon by an agreement between the manufacturers and dealers of machine tools, in accordance with which the German Machine Tool Builders' Association each month settled upon a certain percentage by which previously quoted prices should be increased for machines delivered during the month. According to this method, a machine quoted at the price of 250,000 marks in December, 1921, with the understanding that the price was subject to a sliding scale, would cost, by the end of March, approximately 350,000 marks, and by the end of May, 550,000 marks

According to the other method adopted, the selling price increased automatically 0.4 per cent for each per cent increase in raw materials, and 0.5 per cent for each per cent increase in wages, up to the time of delivery. In accordance with this scale, a machine quoted in December at 250,000 marks would have been sold in May for approximately 350,000, a price much lower than that determined by the other sliding scale.

These sliding prices have made it very difficult to buy with any assurance as to what the cost would be at the time of delivery. Some machine tool manufacturers took orders toward the end of last year at fixed prices, and they have suffered great losses on account of the increased cost of materials and the increases in wages. There is no expectation of any decrease in the prices of machine tools for a long time to come, but on the other hand, a steady increase is almost a certainty.

More rigid terms of payment are being stipulated at present. Usually one-third of the total amount is required with the order, one-third when the machine is ready for shipment, and one-third within ninety days. In many cases the last third is requested within thirty days after delivery.

Organization of the German Machine Tool Industry

The whole German machine industry is now divided into twelve principal groups or trade associations of which the Association of German Machine Tool Builders is one. This association, in turn, is divided into smaller groups, each devoted to some specific line or type of machines. The formation of these groups have proved very useful in determining upon export prices for different classes of machines to different countries. Much technical work has also been done within these groups, one outstanding example being the standardization activities in the drilling machine field. During the past year the association has also maintained a special news service for its members through which any news that seems to be important to the machine tool builder is quickly forwarded to him. This service is said to have been very successful.

The association decided, beginning in October, 1921, to sell for export in foreign currency. The machine tool dealers also agreed to this decision, and the machine tool industry has been the first German industry to sell abroad in foreign currency. It is stated that the exports have been considerably aided by this method.

General Prospects in the Industry

One of the serious drawbacks for the future development of German industry is the shortage of working capital. The banking interests have requested all industrial works to restrict their activities, if their present working capital does not allow them to maintain the production on the same scale as in the past. There appears to be plenty of foreign capital in countries adjacent to Germany waiting for an investment opportunity; but as yet no one ventures to invest in Germany because of the uncertainty of the political aspect and general economic conditions. The trade unions are constantly acquiring greater political influence, and are using it in a way that makes many fear for the peaceful solution of all the difficulties that at present beset German industrial life. There is considerable fear of a Soviet movement in Germany, which would mean industrial ruin.

The Machine-building Industries

THE industrial improvement manifested since the beginning of the year rests upon solid foundations; otherwise, there would have been a collapse from the strain upon the industrial structure during the summer months, as a result of strikes in two of the most important fields of activity. "The outstanding feature of the month," says the Federal Reserve Board, "has been the inherent soundness which the general business situation has manifested in the face of the difficulties encountered. This has been shown by the continuance of activity at a relatively high level despite labor disturbances." The Department of Commerce voices the same opinion by saying that "No clearer demonstration could be asked to indicate the soundness of the fundamental conditions underlying the present business revival than the persistence with which commerce and industry have progressed in the face of recent serious obstacles. The extremely serious labor difficulties through which we are now passing would, under many conditions, have completely demoralized business; instead, real progress continues to be made." Direct observation of conditions in the machine-building field bear out the truth of these statements; but at the same time it must be understood that business must necessarily proceed under handicaps for some time to come as a result of the fuel shortage and transportation difficulties.

The Machine Tool Industry

The demand for machine tools, which fell off somewhat in August—much of the falling off being seasonal—showed an increase in September. Buyers of shop equipment no doubt have held back purchases, expecting further price reductions; and finding themselves, instead, in a rising market, there is no longer any reason for delay in buying. Several manufacturers of engine lathes, turret lathes, and shapers have increased their prices, and further price advances are expected in these and other lines. These advances are necessitated by changed conditions. The cost of materials has increased considerably; and wages, instead of coming down, are in many instances being increased in the machine shop field. The level of wages in the machine industries has been lower than in other fields, which has made adjustments necessary. All this tends to force an increase in machine tool prices.

Conditions in the machine tool industry vary considerably according to the types and sizes of machine tools built. We find shops—especially those whose product directly or indirectly serves the automobile industry—working full time and even employing night forces. One manufacturer of heavy machine tools finds the improvement so marked and steady that normal business in his line of machinery is expected early in 1923. Another manufacturer of a standard line of high-grade machine tools states that the amount of business for 1922 will equal that of 1915, and in several other instances the pre-war level of production has been reached, with a steady improvement reported. On the other hand, we find shops where the improvement up to the present time has been very slight, and prospects as yet do not promise any large amount of business for some time to come; but fewer machine tool builders now say that there is no business at all than at any time during the last eighteen months. The resumption of work in the machine tool shops is retarded in some instances, not by lack of orders, but by the large stocks still on hand of certain types of machines. However, these stocks have been gradually reduced, as have also those in the dealers' hands, and when conditions today are compared with those of a year ago, optimism should be the keynote.

On the whole, the fact is that in the machine tool industry business is picking up, and there will be a fair amount of railroad buying as soon as the strike is settled, the railroads having already placed several orders. The Pennsylvania Railroad is said to be planning a large increase of its Altoona shops and the re-equipment of many of the smaller shops, which, by itself, would provide a large volume of business in railroad shop machinery.

Orders placed by the railroads for locomotives and freight and passenger cars during the last two months are quite large, and the locomotive builders are well employed. This, in turn, has resulted in orders for machinery used in locomotive building. The present unfilled orders for domestic locomotives are the highest recorded since November, 1920.

General Conditions in Allied Fields

The small tool business has not improved as rapidly as was expected, but it must be remembered that in this field business never receded to as low a level as it did in the machine tool field. Several small tool concerns report that their business is now from 50 to 60 per cent of normal. In the case of some of the largest manufacturers, the percentage is not quite so high. Railroad buying is more active in the small tool field, because, while railroad shops can get along with the old machine tools, they must replenish their small tools, for these will break or wear out.

Higher prices for small tools are expected for two reasons: The price reductions made were too great, and tool steel prices are expected to increase. Certainly, they will not be any lower, and this should be a good time to stock up with tool steel at low prices. Aside from the railroads, the automobile industry has been the chief customer of the small tool shops.

The file business is steadily improving, and some of the largest plants in this field operate at from 70 to 75 per cent of capacity. The price situation in this field is also more satisfactory. Price increases have placed the selling price on a more rational basis, as compared with production costs. The same is true of the gear business. One of the largest firms in this business in running at 75 per cent of capacity. Other gear manufacturers are occupied all the way from 45 to 100 per cent of normal. The business in gear-cutting machinery is also improving, the demand having steadily increased for the last six months.

One firm engaged in making transmission equipments states that the present business is equal to the volume handled before the war, but due to increased facilities this is only from 50 to 60 per cent of present capacity; a steady improvement is noted. The bearing metal business is from 65 to 75 per cent of normal.

The crane and hoist business is good. One of the well-known firms engaged in this business states that August brought more business than any month since March, 1920, and that September promised to exceed the previous month.

The Labor Situation in the Machine-building Field

One of the difficulties encountered by the machine tool industry is the scarcity of skilled labor, which is now very apparent. Good machinists and toolmakers are scarce, a fact which is reflected in wage advances. The cost of training new men in the machine tool shops will run high. Skilled mechanics formerly employed in this industry are now generally employed in machine shops building other lines of machinery or apparatus, and many have entirely left the machine-building trade and turned to other occupations. Hence, the actual cost of production is bound to be materially higher.

New Machinery and Tools

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Chambersburg Punching and Shearing Machines

The distinguishing features of this line of power-driven punching and shearing machines are an automatic electric clutch control and an adjustment for the stroke of the sliding head. The clutch control is operated from the front of the machine, and so the operator need never leave his working position. The machine can be stopped at the end of each stroke or operated continuously. The stroke adjustment is effected through the control head, without the use of cams.

A line of vertical punching and shearing machines on which settings and adjustments of the sliding-head stroke are quickly made by means of a patented electric clutch control has recently been developed by the Chambersburg Engineering Co., Chambersburg, Pa. A double-end machine equipped with the electrical control is illustrated in Fig. 1. This line of equipment is so designed that machines of different capacities may be operated end to end, as well as machines of like capacity. Belt-driven machines may also be provided with a mechanical pedal control, as illustrated in Fig. 4, instead of the electric control. However, this control is recommended to be used only when proper electric current is not available.

The stroke adjustment is made at the head end of the machine when the control head *A*, Fig. 2, is in the adjusting position shown, at which time the electric circuit has been automatically opened, and the clutch disengaged. The stroke adjustment is then made by positioning around cap *B*, a headless set-screw which is exposed. Cap *B* has graduations which indicate the position at which the stroke will be ended when the set-screw has been brought to that graduation.

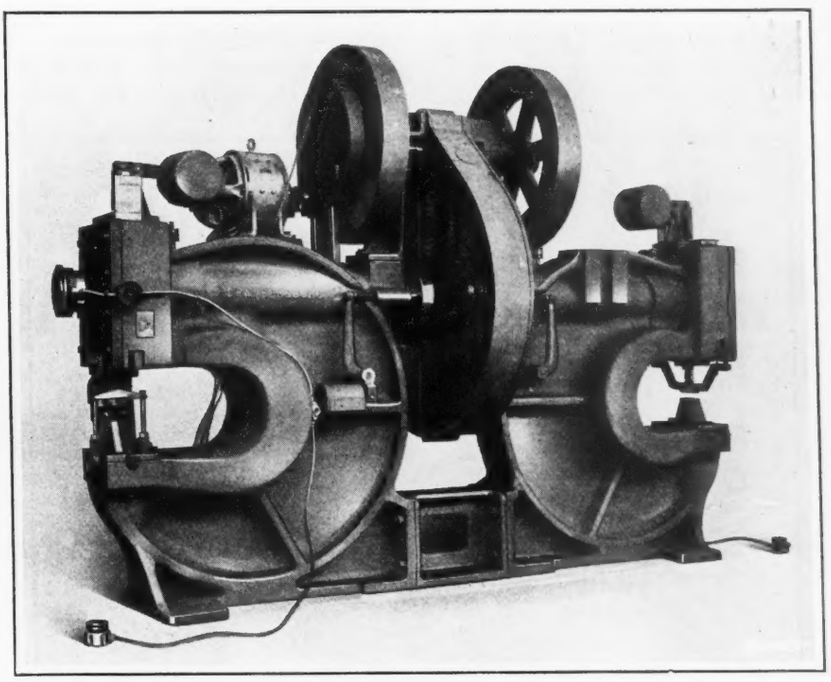


Fig. 1. Chambersburg Double-end Motor-driven Punching and Shearing Machine arranged with a Patented Electrical Control

Fig. 3 shows the control head in the position it occupies when the machine is in operation. A momentary depression of button *C* causes the engagement of the clutch, and this member is automatically disengaged as the sliding head reaches the point indicated by the setting of control head *A*. The machine may also be operated continuously. A portable push-button switch is also provided for operating by either hand or foot. The clutch disengages as a safety measure in case the electric circuit fails. With this automatic control it is unnecessary for an operator to leave the front of the machine while punching or shearing work.

The clutch is of the solid-jaw renewable-face type. The sliding half is a steel casting and the fixed half is cast integral with the large gear and reinforced by a steel ring shrunk into place. The machine frame is an I-beam type semi-steel casting with a solid jaw, large back flange and generous fillets to provide maximum rigidity and strength. The absence of cores precludes undetected faulty sections in the casting. The sliding head is also a semi-steel casting and has a bronze take-up wedge. The head is counterweighted by springs and actuated through a

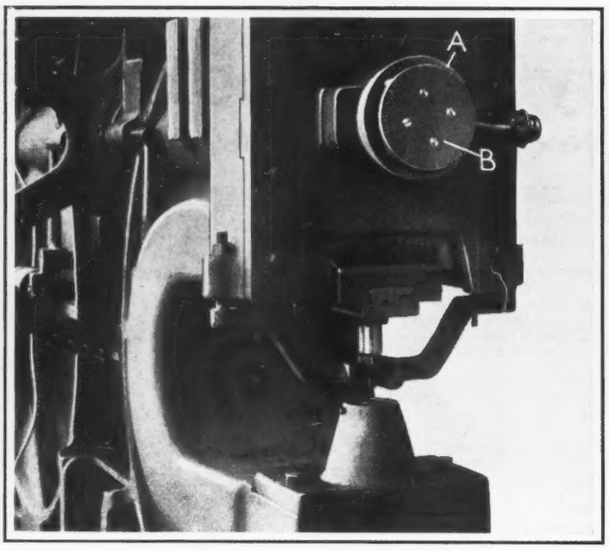


Fig. 2. Control Head in Adjusting Position on a Punching Machine

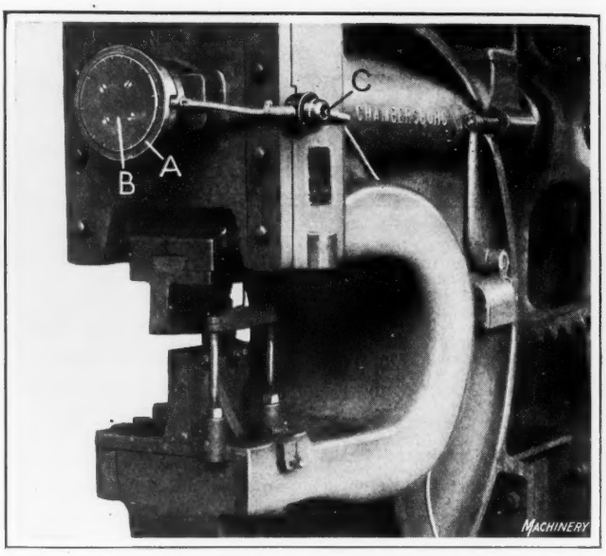


Fig. 3. Shearing Machine with Control Head in Operating Position

manganese-bronze eccentric box which minimizes lateral strains. The head cap is tongued to the frame and held by fitted screws. The eccentric shaft is a one-piece steel forging, accurately finished, which rotates in large bronze bushings. The main bearings and the sliding head are lubricated by sight-feed oil-cups, and oil-grooves provide for the efficient distribution of the oil.

The machine-molded gears are made of semi-steel, the pinion being shrouded. Fractional ratios insure the alternate stressing of the gear teeth. When a machine is motor-driven, a cut steel gear is furnished on the motor shaft. Gear guards may also be supplied. A one-piece safety capstan provides for turning the eccentric shaft by hand, and for camming the capstan bar out of the capstan, should the machine be accidentally started. The driving shaft is turned from machine steel, and runs in babbitted bearings. The tool-blocks are made of cast steel, the upper block being tongued to the sliding head and the lower block bolted to the frame. All tool-blocks are interchangeable on machines of like capacity. A patented floating punch which combines a fixed and a floating punch in one tool facilitates spacing table work. A tool-block can be removed in an instant by a quarter turn of a handle.

This line of machine is made in eight sizes, the smallest of which has a capacity for punching a ⅝-inch hole through mild steel plate ½ inch thick; shearing 3- by 9/16-inch flat stock, 1⅛-inch round stock, and 2- by 2- by 3/16-inch angle-iron; and splitting plate up to 7/16 inch thick. The standard throat dimensions are 6, 12, 18, and 24 inches. The largest size machine has a capacity for punching a 2½-inch hole through mild steel plate 1 inch thick; shearing 8- by 1¼-inch flat stock, 2½-inch round stock and 6- by 6- by 11/16-inch angle-iron; and splitting plate up to 1 5/16 inches thick. The standard depths of throat for machines of this size are 15, 24, 36, and 48 inches.

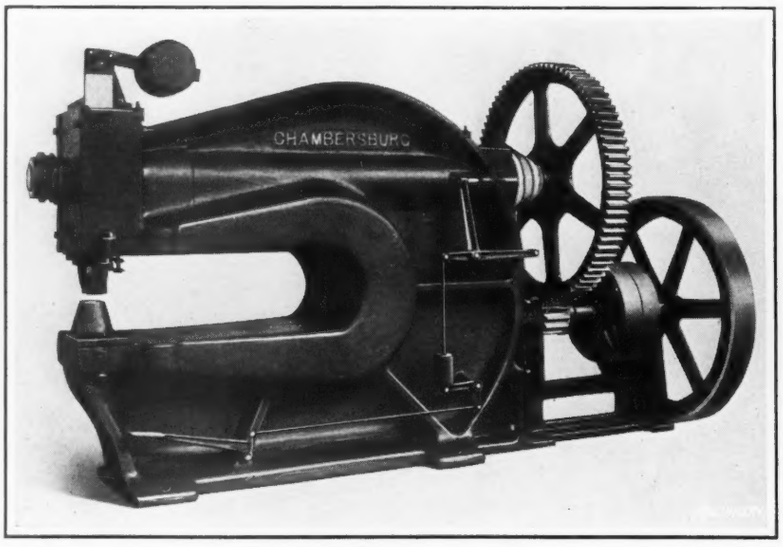


Fig. 4. Single-end Punching Machine with Mechanical Clutch Control and Belt Drive

VAN NORMAN AUTOMOBILE-VALVE GRINDING MACHINE

A small self-contained equipment for grinding automobile engine valves in service stations and garages has just been brought out by the Van Norman Machine Tool Co., 180 Wilbraham Ave., Springfield, Mass., under the trade name of "Valvo." From Fig. 1 it will be seen that belts are entirely eliminated, both the work- and grinding-wheel heads being driven by individual motors. The grinding wheel is mounted directly on the shaft of a ⅛-horsepower ball-bearing motor which runs at 3450 revolutions per minute and is rigidly attached to the base of the machine, while the work-head spindle is driven through gearing from a 1/20-horsepower motor. The work-head unit is carried on a movable slide operated by turning the lever at the left of the machine. The grinding wheel is 6 inches in diameter by ⅜ inch thick.

A valve to be ground is held by the stem in a split draw-in collet chuck which receives stems up to 9/16 inch in diameter. After the valve has been tightened in the chuck and the work-head set at the proper angle by means of graduations which run up to 60 degrees, the grinding is done by passing the valve across the face of the wheel, as shown in Fig. 2. This is accomplished by imparting a backward and forward movement to the lever. At the same time, the work is fed against the grinding wheel by revolving the handwheel on the base of the work-head. The average valve can be reground in one minute. The reamer for the valve seat can also be ground at the same setting, thus insuring proper seating of the valve. In addition to grinding valves, the machine is well adapted for grinding other parts, such as ignition contact points, tappet screws, and other short pieces. The main slide and the cross-slide are planed and scraped. The taper spindle of

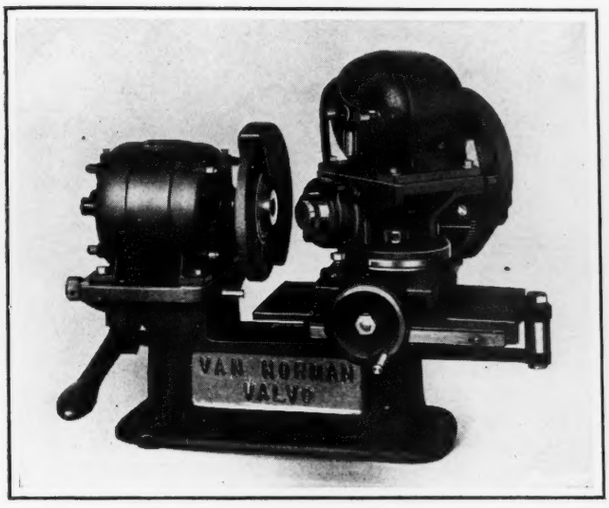


Fig. 1. Van Norman "Valvo" Grinding Machine designed for grinding Automobile Engine Valves

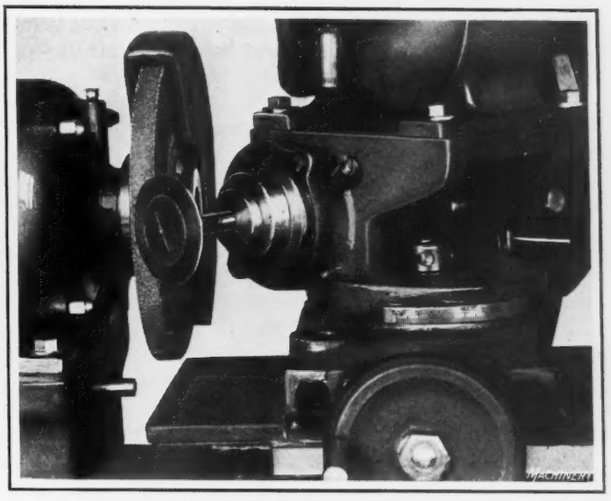
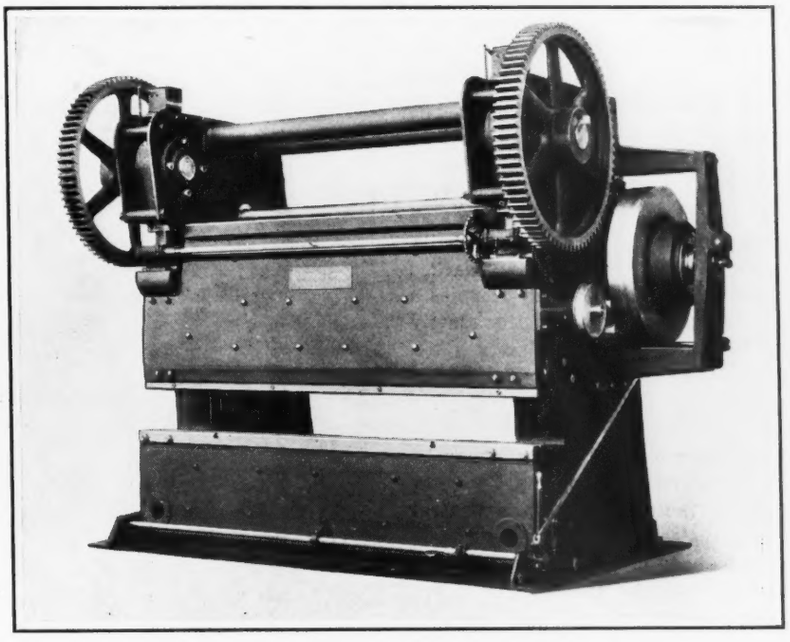


Fig. 2. Close-up View, showing the Manner of contacting the Valve with the Grinding Wheel

the work-head is carefully ground, and has provision for taking up wear. The small amount of power required for driving the motors makes it possible to use a lighting socket for supplying the electric current. An adjustable screw-stop may be used to control the depth of grinding. A convenient push-button is operated to lock the spindle in place when tightening the collet chuck. The intermediate gear between the work-head motor and its spindle is made of fiber to insure a smooth- and quiet-running machine. The over-all dimensions of this machine are as follows: Length, 20 inches; width, 15 inches; and height, 16 inches. The machine weighs about 110 pounds.

CINCINNATI POWER PRESS BRAKE

A power press brake for bending the edges of sheet steel and iron, which has an extensive application in the manufacture of such products as metal furniture, steel railroad cars, metal window sashes, etc., is here illustrated. This machine has recently been developed by the Cincinnati Shaper Co., Elam St. and Garrard Ave., Cincinnati, Ohio, and is made in sizes of from 6 feet 6 inches to 14 feet 6 inches between housings, for handling material from No. 10 gage to ¾ inch in thickness. The machines have capacities of from 80 to 600 tons. The frame is of all-steel construction, and as many members as possible are welded together to insure rigidity and strength. The bed and ram are constructed entirely of steel plate and bars, which are welded to each other to form what is virtually a heavy solid steel beam of box section. The housings are built from steel plates and cast-steel members, which are interlocked and welded to the plates. The cast-steel members have heavy trunnions for supporting the bed. Where bolts are used in solid members to hold the plates in place, the bolts are welded as well as the plates so that all chance of their working loose is eliminated. Parts are bolted together only when convenience of assembly requires it. The chief advantage of welding the steel plates and castings together is that maximum strength is obtained with minimum weight.



Cincinnati Power Press Brake for bending the Edges of Sheet Steel

The ram extends across the entire front of the machine. It is operated by a vertical arm at each end, which is reciprocated by means of a short eccentric shaft driven through reduction gears on the outer side of the housing. Power is transmitted to the left side of the machine by a long shaft, the machine being driven at the right end through a multiple-disk friction clutch having a simple adjustment. This clutch has repeatedly picked up a full load instantly, that is, with the ram down against the work. It can be operated by a hand-lever or by depressing the foot-treadle on the splined trip-shaft extending along the front of the bed. The treadle is adjustable along the trip-shaft to suit the convenience of the operator.

All power-driven shafts are made of high-carbon steel, and their bearings have automatic sight-feed lubrication. The eccentric shafts are forgings and the eccentrics are integral with the shafts. The ram is gibbed endwise as well as sidewise, a provision which is essential when using the machine as a gang punch. Adjustment of the ram is obtained through worm-gearing running in oil. In a motor-driven machine, the motor is mounted on a bracket attached to the right-hand housing, the driving belt being held in tension by a weighted idler pulley. Open-throat housings permit the forming of sheets of greater width than can be passed between the housings. Thus, for most classes of work, the machine may be rated with respect to the length of the die-holding surface instead of the distance between the housings. The clear space between the

housings at the rear may be readily utilized for stacking finished parts. When more than one operation is necessary on a piece, the work may be passed back and forth through the machine, thus avoiding the inconvenience of turning the work end for end. The weight of the machine ranges from 9 to 60 tons according to its size.

NOBLE & WESTBROOK MARKING MACHINE

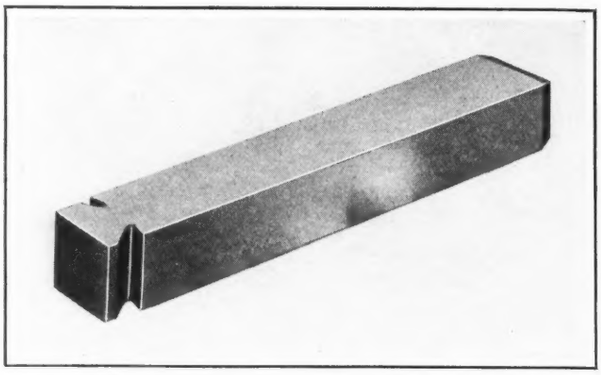
Four lines of lettering 1/16 inch high can be marked on round pieces up to 2 inches in diameter and also on flat pieces by the use of a small No. 13 bench-type marking machine, which is a recent product of the Noble & Westbrook Mfg. Co., Hartford, Conn. The marking is done by means of steel dies. On flat pieces the die rolls over the part being marked, and on round pieces, both the die and the work roll together. The design is similar to that of

Noble & Westbrook Small-sized Marking Machine

other marking machines manufactured by the same concern, except that the pressure is applied from the top by a cam movement operated through a rack and pinion, and not by means of the table, as in the larger models. The slide is fitted with roller bearings. The table is raised or lowered by means of a handwheel graduated in thousandths of an inch, and is locked in the desired position. Small drills, reamers, knives, chisels, and similar parts may be marked at the rate of about 700 per hour. The machine occupies a space of 10 by 12 inches, and its weight is approximately 60 pounds.

SMITH & SERRELL SELF-FITTING KEYS

The fitting of keys in the assembly of two parts may be eliminated by using a line of "Keytite" self-fitting keys now being placed on the market by Smith & Serrell, 46 Central Ave., Newark, N. J. A key typical of the larger sizes is shown in the illustration. The body of these keys is ground several thousandths inch wider than the nominal size of the keyways, and near the front end are two cutting edges and chip recesses. The width of the key at the front end is slightly less than the nominal width of the keyways to



"Keytite" Key which shaves the Sides of a Keyway to insure a Tight Fit

permit this end to serve as a pilot when driving the key into place. The key is inserted in the keyways with the cutting edges on the sides, and as the key is driven into place these cutting edges shave sufficient material from the keyway of both parts being assembled to insure a tight fit. The keys are furnished in nominal widths of from 3/16 to 3½ inches. The smaller sizes have only one cutting edge.

Keys with heads may be supplied for cases in which headless keys cannot be drifted out, or many of the larger sizes may be tapped to permit their removal by means of a bolt. Taper keys may be supplied with or without heads. On heavy-duty work in which the keys must be fitted on the top and bottom, as well as on the sides, they may be supplied with cutting edges for the four surfaces.

VICTOR COLLAPSIBLE PIPE TAPS

An improved line of receding-chaser collapsible pipe taps is being introduced to the trade by the Victor Tool Co., Inc., Madison and W. M. R. R., Waynesboro, Pa. These tools are adapted for tapping pipe threads in forged-steel flanges, fittings for ammonia and high-pressure lines, couplings, casing shoes and heads, etc. The stationary type is illustrated in Fig. 1. As in the original design described in April, 1920, MACHINERY, short chasers are used for cutting a Briggs tapered pipe thread, instead of ordinary tapered chasers. These chasers are receded radially into the holder as the tap enters the work, by means of a trip-collar set against the face of the work prior to the operation.

As the tap feeds into the hole, the collar is pushed back along the body. The collar has cam-blocks which engage a plunger at the center of the tool, and the chasers are mounted at the forward end of the plunger on tapered surfaces. Thus as the collar is pushed back it imparts a similar movement to the chaser plunger which results in

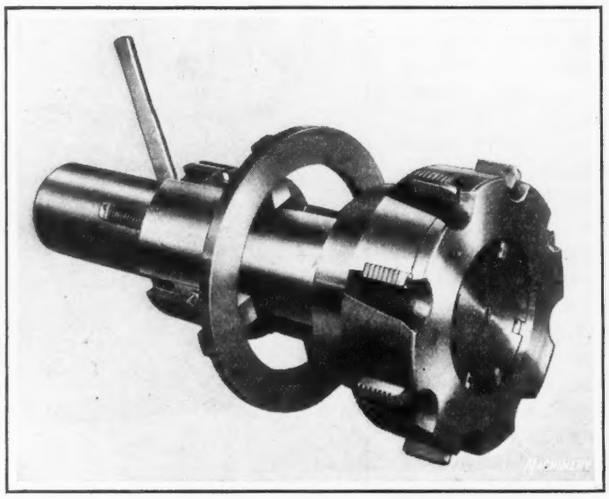


Fig. 1. Victor Stationary-type Receding-chaser Collapsible Pipe Tap

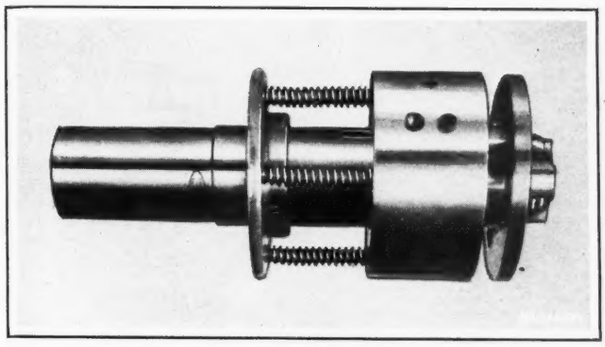


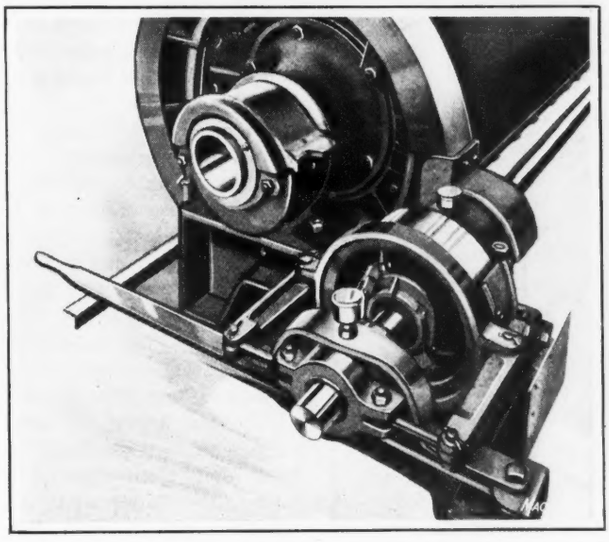
Fig. 2. Rotary Type of Pipe Tap in which the Chasers recede into the Body

the chasers receding toward the center of the tap. Formerly, there was only one cam-block, but by the addition of a second block, which works in conjunction with the first, the receding of the chasers is said to be more positively controlled and a uniform taper is insured in the thread being produced. It is possible to cut a tapered thread of any desired length. The design of the cam-blocks has also been altered to make them more efficient.

The rotary-type collapsible tap of this style, Fig. 2, has also been changed considerably. In this design, a ring or collar is employed for setting the collars and chasers in position for cutting, instead of a detachable lever. By pressing forward on this collar by hand or by having an attachment on the drilling or tapping machine come in contact with it when the machine spindle is raised, the chasers may be set without stopping the machine. There are no projections on the device, so that it conforms with all safety laws. All taps have an adjustment range of 1/16 inch either over or under size. This tap is said to require considerably less power for driving than the ordinary taper-thread tap, due to the reduced length of the chasers. These taps are made in all sizes from 1¼ to 12 inches in diameter.

COMBINATION CLUTCH AND BRAKE FOR TUMBLING BARRELS

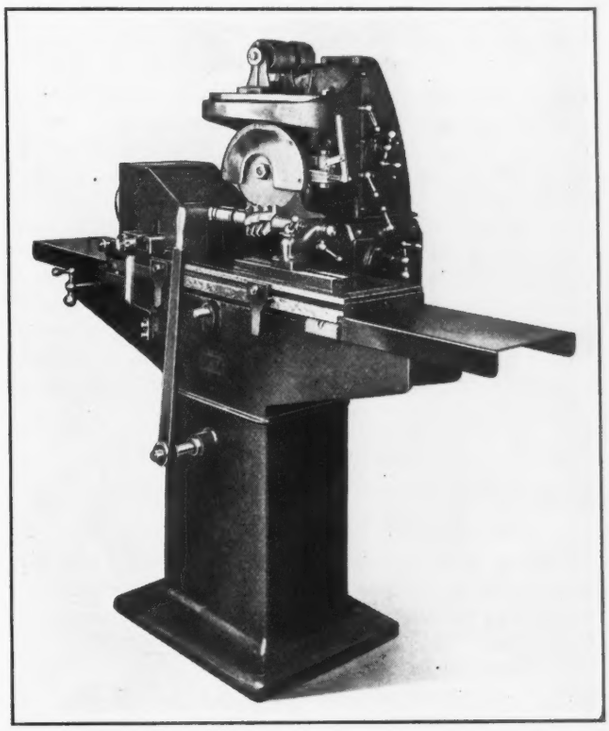
In unloading work from tumbling barrels, it is common practice to hold the barrel in the desired position by a wood prop, by inserting a bolt between gears, or by some other makeshift method. The accompanying illustration shows a combination clutch and brake by means of which the rotation of a tumbling barrel may be stopped immediately, when the operator manipulates the lever. This device also prevents the barrel, when unequally loaded from turning after having been stopped. The clutch is engaged and the barrel revolved when the controlling lever is pushed toward the barrel, and when the lever is pulled in the opposite direction the barrel is stopped. This mechanism has been placed on the market by the Whiting Corporation, Harvey, Ill.



Combination Clutch and Brake for controlling the Rotation of Tumbling Barrels

HARRIS SEMI-AUTOMATIC HOB-GRINDING MACHINE

For use in shops where the quantity of hobs and form cutters to be ground does not warrant the installation of the full-automatic hob-grinding machine built by the Harris Engineering Co., Bridgeport, Conn. (described in February MACHINERY), this concern has brought out a No. 10 semi-automatic hob-grinding machine. It will be seen from the illustration that the design of the new machine is similar in several respects to the automatic type. The hob or cutter



Harris Semi-automatic Machine for grinding Hobs and Form Cutters

to be sharpened is carried on an arbor provided with a taper shank that fits the work-carrying spindle, the outboard end of the arbor being supported by the center of an adjustable tailstock. The work-spindle and tailstock are mounted on a long table which is operated to and fro by means of a hand-lever on the base. The table is carried by ball-roller bearings of special design which are said to render the action so sensitive that the operator can tell from the feel of the lever if the grinding is too heavy or too fast. Stops limit the stroke of the table to suit the length of the hob.

Hobs having helical flutes are given a rotary movement during the travel of the table by a sine bar which can be instantly adjusted to different angles. This sine bar actuates a cross-slide carrying a rack that meshes with a gear on the work-spindle. Index-plates are used to set the rows of teeth for grinding; these plates have two sets of notches, one for indexing and the other for escapement. The index-plate must have the same number of notches as there are gashes or flutes in the hob to be ground. The indexing mechanism is semi-automatic and can operate only at the end of the return stroke. At this point the operator pulls a handwheel at the left end of the machine as far toward him as it will go, and the hob is then indexed to the next flute.

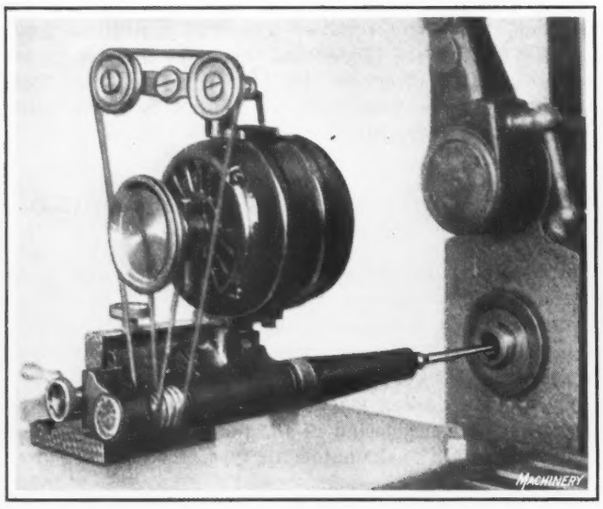


Fig. 1. Precision Thread Grinder equipped with an Extended Housing and Spindle Attachment

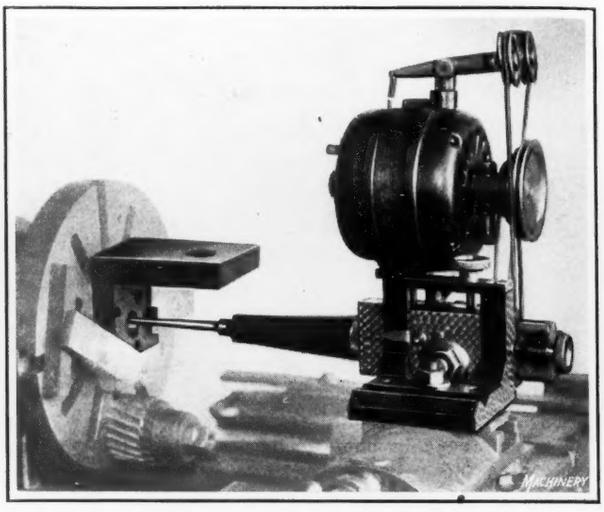


Fig. 2. Using the Extension in grinding the Hole of a Part having a Long Projection

The wheel-head is provided with all the necessary adjustments and graduations for obtaining settings and compensating for wear. A diamond truing device is built into the head, which can be used when the machine is in operation without disturbing the work. This device can be set for truing the wheel to grind the faces of the hob teeth radially or with a top rake. The hob is fed against the grinding wheel by turning a handwheel. Some of the principal specifications of this machine are as follows: Table travel, 15 inches; maximum diameter of work, 8 inches; maximum length of work, 10 inches; range of flutes in hobs, 4 to 26; size of grinding wheel, 8 inches by 1 inch; and approximate weight of machine, 1760 pounds.

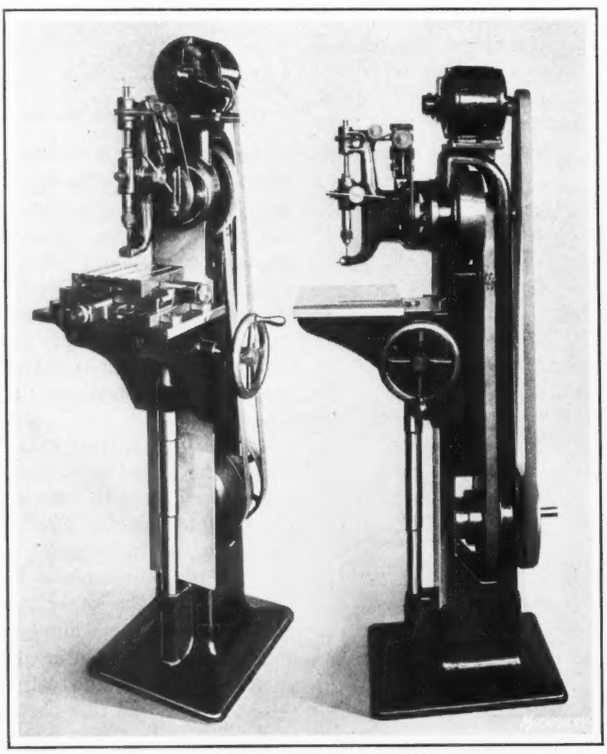
EXTENSION HOUSING AND SPINDLE FOR PRECISION THREAD GRINDERS

Multi-graduated precision thread grinders of all types manufactured by the Precision & Thread Grinder Mfg. Co., 1 S. 21st St., Philadelphia, Pa., may now be equipped with an extension housing and spindle that enables internal grinding operations to be performed to a depth of 12 inches on holes 2 inches or greater in diameter and to a depth of 6 inches on holes ½ inch in diameter. The new attachment is especially applicable for grinding the tapered bore in milling machine spindles, as illustrated in Fig. 1. Concentricity of this bore promotes full service and long life of the cutters, especially in the case of unhardened spindles.

Lathe-spindle taper bores also require truing occasionally to correct errors in concentricity and alignment, and these bores may be trued by means of the attachment. Fig. 2 shows a grinder equipped with the extension housing and spindle attachment being used in a lathe for grinding a hardened part having a projection that would interfere with the operation if the grinder were not provided with the extension. The extension housing is screwed on threads at the front of the regular spindle cap of the grinder. The extension spindle is coupled to the regular spindle by means of taper joints, and is supported at the working end of the extension housing by radial and thrust ball bearings. The spindle support is of sufficient length to insure rigidity at the grinding end of the spindle.

KRAG LAYING-OUT AND DRILLING MACHINE

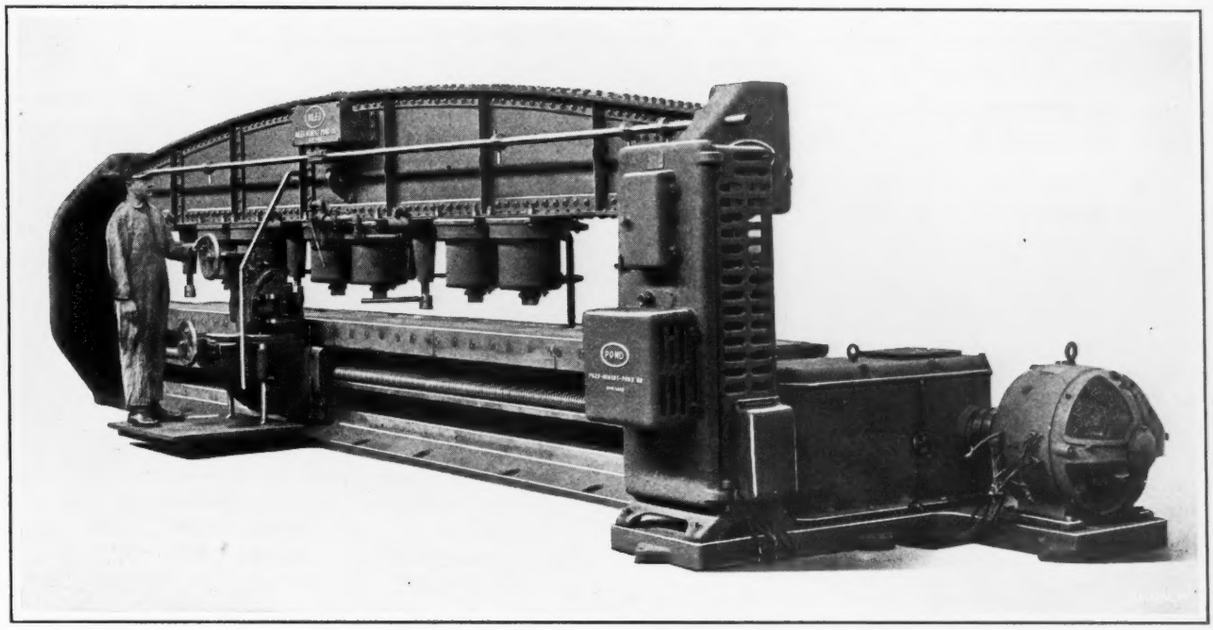
Dies, jigs, templets, master plates, and other tool-room work in which holes must be accurately laid out and drilled, can be quickly handled on the "K-N" laying-out and drilling machine here illustrated, when the machine is equipped with a Johansson compound slide, as shown at the left. This slide is used in conjunction with gage-blocks. The machine is being placed on the market by E. L. Krag & Co., 50 W. Randolph St., Chicago, Ill. It is stated that with this machine holes may be laid out and drilled in one-tenth the time required by the button method.



Krag Laying-out and Drilling Machine for Tool-room Work

The head of the machine swivels through 360 degrees, allowing locating and drilling to be done at any degree about a circle. An interchangeable drill bushing is supported in a rigid arm that is integral with the head casting. As this bushing is immediately above the work, any tendency of the drill to spring is eliminated. The machine has six changes of speed ranging from 400 to 4300 revolutions per minute, and thus furnishes the proper speed for drills up to ¼ inch in diameter.

Without the Johansson compound slide and gage-blocks, the machine becomes a precision high-speed drilling machine with a swinging head and with the drill guided immediately above the work to insure accuracy. The head is so constructed that it can also be removed from the



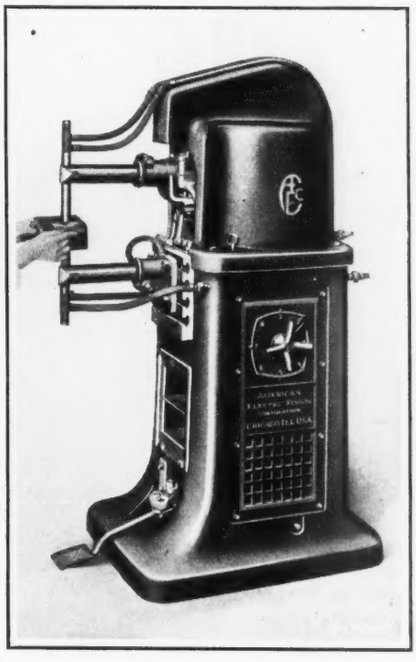
Niles-Bement-Pond Plate Planer of Improved Design

column and quickly mounted on a milling machine for laying out and drilling. As a routing and milling machine, the equipment works well with a single-lip cutter. A screw is provided for locking the spindle in a fixed position. A spring idler keeps the belt at the proper tension at all times, allowing the belt to slip if too great a pressure is exerted on the cutter and thereby saving the cutter from breaking.

NILES-BEMENT-POND PLATE PLANER

The principal improvements in a new line of plate planers now being built by the Niles-Bement-Pond Co., 111 Broadway, New York City, include a redesigned bed and tool carriage. The primary object for redesigning these members was to prevent chips from getting on the carriage screw. The tool carriage is attached to the front of the bed and guided along it by means of square ways. It is secured at the top and bottom by removable bearing supports, the bearing surfaces of which have taper gibs for taking up wear. There are two relieving tool-holder slides which may be simultaneously adjusted vertically and horizontally by turning handwheels seen at the front of the machine. Both of the tool-slides can be swiveled so as to permit the planing of bevels.

The driving screw is supported in a trough having an oil channel of sufficient depth for the oil to reach to the full depth of the thread. Roller bearings take the end thrust of the screw. The carriage is reversed automatically at any desired point by coming in contact with stops which are adjustable on a shifter-rod. The operator can start, stop, or reverse the carriage by manipulating this shifter-rod by hand. The motor is controlled by a master switch attached to the shifter-rod, and an enclosed panel with a forward, reverse, accelerating and dynamic-brake contactor. A push-button switch on the right-hand housing permits the machine to be started and stopped without manipulating the shifter-rod. The main driving gears are enclosed in a box and run in oil. The pneumatic jacks are of a two-way type in which air is admitted at the top for clamping the plate, and at the bottom for unclamping it, a feature that is considered a valuable improvement.



"A. E. F." Spot Welding Machine with Rocking Upper-electrode Holder

AMERICAN SPOT WELDING MACHINE

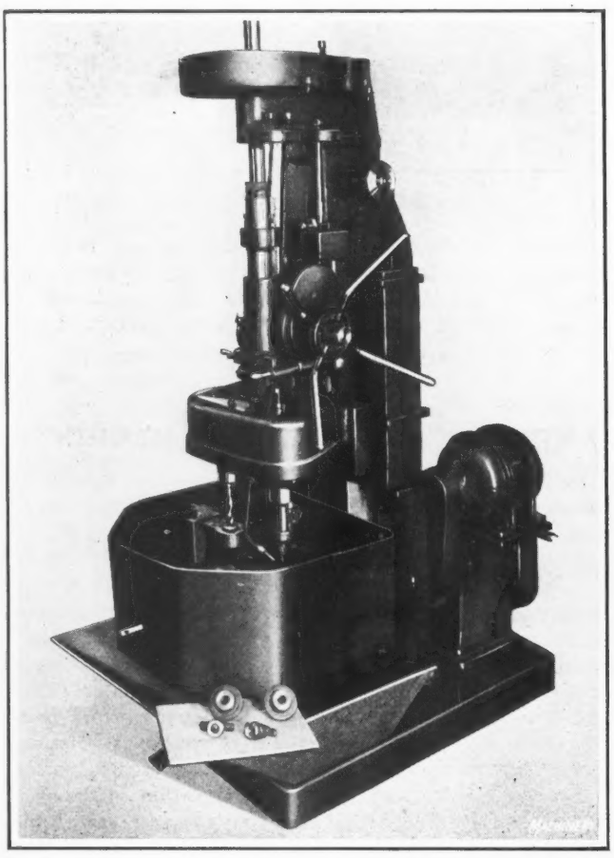
The main feature of a spot welding machine now being introduced to the trade by the American Electric Fusion Corporation, 972-982 Montana St., Chicago, Ill., is the mounting of the upper electrode at the end of a rocking arm which is lowered on the work by depressing a foot-treadle. This arm is mounted on bronze-bushed trunnions which are lubricated by the Alemite pressure-lubricator system. The arm is balanced by a counterweight to lessen the exertion of the operator. An automatic switch closes when the electrodes grip the work and opens before pressure on the foot-treadle is released. An adjustable compression spring device permits regulation of the grip on the work and the pressure at the weld. The electrodes consist of die-formed one-piece copper parts.

The electrical contact is entirely independent of the mechanical grip, and positive contact is assured at all times. The lower horn is water-cooled and of a design which allows the use of a short electrode. All moving members and high-voltage electrical parts are completely enclosed to insure safety. The square faceplate on the front of the machine has T-slots in it to permit the mounting of jigs and special fixtures. A heat regulator furnishes eight different speeds of welding to suit all thicknesses of metal within the capacity of the machine. The automatic switch and connections are accessible through a door at the rear of the column, and other interior parts through a panel on each side of the column. The length of the treadle-rod may be increased to suit the convenience of the operator.

ROCKFORD DRILLING MACHINE WITH ROTARY TABLE

A four-station rotary table and a three-spindle head are shown in the accompanying illustration applied to the 20-inch box-column drilling machine built by the Rockford Drilling Machine Co., Rockford, Ill. This arrangement adapts the machine for performing economically three successive operations on parts. The particular set-up illustrated is employed for machining the yoke and flange members of a universal joint. The successive steps are as follows: Rough-drill; rough-taper-ream and face; and finish-taper-ream. The rough-drilled hole is ¾ inch in diameter and 2⅝ inches long. The production per ten-hour day is 250 pieces.

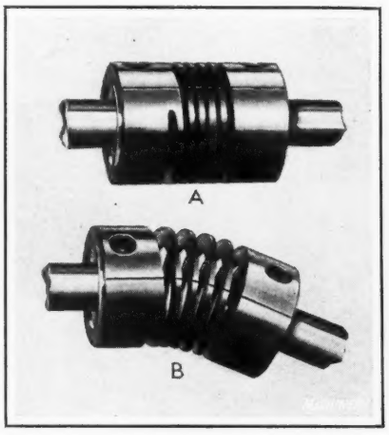
The rotary table is mounted on the regular table of the machine, and indexed by hand after a locating plunger has been withdrawn. Four chucks are mounted on the rotary table and each of these is supplied with two jaws formed to suit the work. During each downward feed of the drill head the finished work in the idle chuck at the front of the machine is replaced by an unfinished part. By means of an extended wrench the chuck screws may be tightened from outside of the chip guard. The drill head is gibbed to the table ways. It is driven and fed by the machine spindl and is counterweighted. A micrometer stop on the spindle quill provides for drilling to a predetermined depth. This machine is regularly rated as having sufficient capacity for drilling a 2-inch hole through solid steel.



Rockford Drilling Machine arranged with Rotary Table and Three-spindle Drill Head

STEEL-FLEX CUT-SPRING COUPLING

A flexible cut-spring coupling made from steel tubing having qualities of toughness and elasticity which adapt it for the transmission of power is now being manufactured by the Steel-Flex Coupling Corporation, 1712 First National Bank Bldg., Detroit, Mich. The coupling is intended for shafts up to 1 inch in diameter which are slightly out of line, or for use where it is desired that the coupling act as a shock absorber against sudden starts. It is particularly suitable for use in directly connecting light-duty motors to such equipment as small drilling machines, blowers, pumps, washing machines, refrigerating outfits, etc.



Steel-flex Cut-spring Coupling

At *B* in the accompanying illustration, the coupling is shown operating at a considerable angle. It may also be used for installations in which the shafts are parallel but have a lateral offset. The same company also manufactures a standard line of coil-spring flexible couplings for shafts from 1 to 12 inches in diameter. The driving coils of these couplings are made from rectangular chrome-vanadium steel bars, tempered to have a high elasticity. The coils are mounted within one another on machine-steel plugs and have steel headers shrunk on the ends to bind them into a flexible unit. Flanges are attached by means of safety cap-screws.

NEWTON FOUR-SPINDLE MILLING MACHINE

A four-spindle knee-type milling machine for simultaneously facing and slotting the crankpin end of automobile connecting-rods has been developed by the Newton Machine Tool Plant of the Consolidated Machine Tool Corporation of America, 23rd and Vine Sts., Philadelphia, Pa. A general view of the machine is shown in Fig. 1, and a close-up view of the work-holding fixtures and the cutters in Fig. 2. It will be seen that six rods are held in a fixture at a time, the three front fixtures being loaded and unloaded, while the parts in the fixtures next to the cutters are being operated on. When the operation has been completed, the

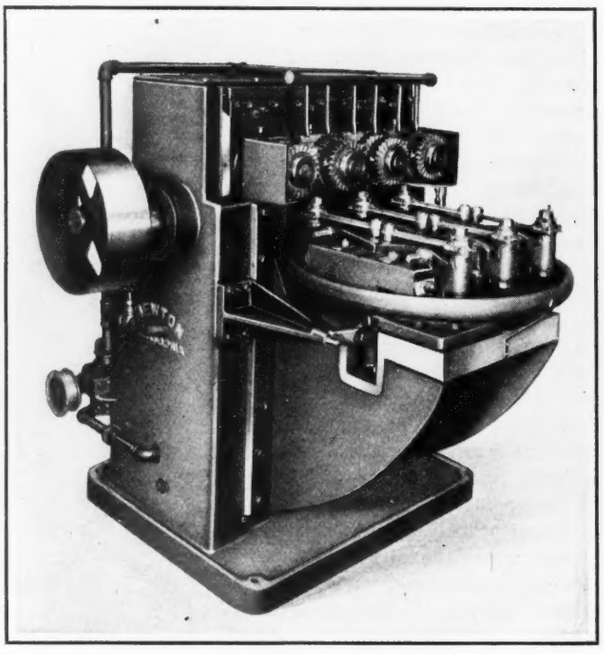


Fig. 1. Newton Four-spindle Milling Machine for facing and slotting Connecting-rod Ends

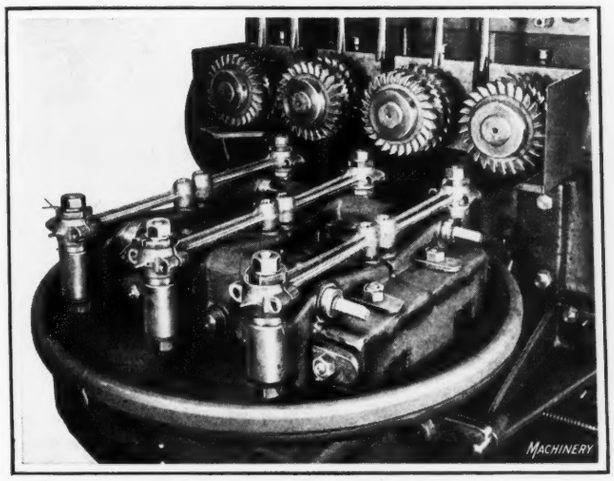


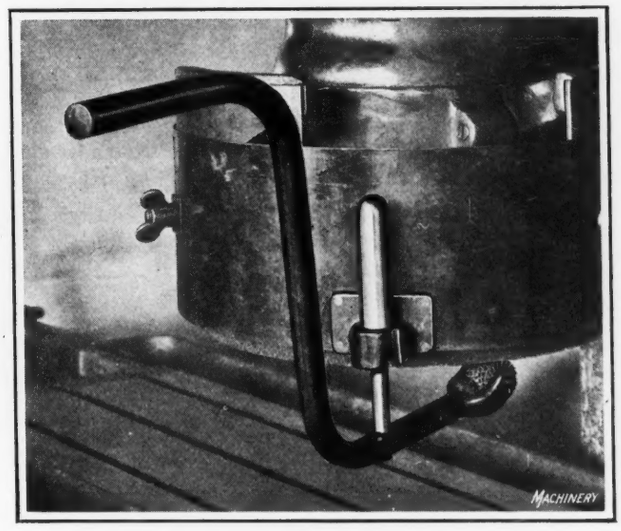
Fig. 2. Close-up View of the Work-holding Fixtures and the Facing and Slotting Cutters

table is indexed to bring the new parts into alignment with the cutters and permit completed rods to be replaced. No time is lost between cuts except the small amount required for indexing the table. Each fixture has an individual adjustment to permit a variation in the distance between rods.

The four spindles have a taper-end construction, are mounted in substantial housings, and have individual adjustments. The adjustments allow an ample variation between the spindle centers to permit the grinding of the milling cutters. The work is fed to the cutters by imparting a vertical feed to the table through change-gears, a worm, a large diameter worm-wheel and a cam. The cam gives a quick upward movement to the knee, a slow feed during the cut, and a quick downward movement. The feed is automatically stopped to allow the table to be indexed, after which the feed is reengaged by means of a hand-lever conveniently located on the right-hand side of the machine. The power is transmitted directly from the driving shaft to the spindles by worm-gearing. The machine is geared to give one cycle of feed in 0.78 minute and to index in two seconds. The production with this gearing is about 225 rods per hour, or, considering the machine efficiency to be 90 per cent, 1620 rods per eight-hour day.

PRATT & WHITNEY GRINDING-WHEEL DRESSER

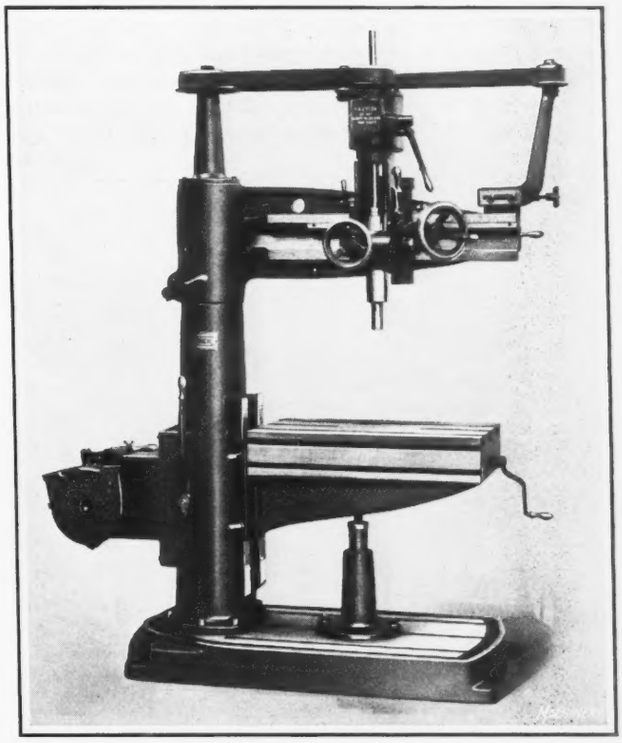
A grinding-wheel dresser of a type commonly employed in hand dressing, but which is mounted on the machine to insure the safety of the operator while dressing a wheel, is shown in the accompanying illustration. This device has been brought out by the Pratt & Whitney Co., Hartford, Conn., for application to the vertical surface grinding machines of its manufacture. It consists of a bracket that is bolted or riveted to the wheel guard to support the stem of the dresser. The dressing wheels are held in the yoked end of a bar, which is bent to fit under the wheel. The other end of the bar is bent to form a handle, by means of which the dresser can be easily moved across the face of the wheel. It is not necessary to make any change in the relation of the work and the grinding wheel when it is desired to dress the wheel, and for this reason the device is quick-acting.



Wheel Dresser for Pratt & Whitney Vertical Surface Grinders

FOSDICK HIGH-SPEED SENSITIVE RADIAL DRILLING MACHINE

The radial drilling and tapping machine shown in the accompanying illustration has recently been developed by the Fosdick Machine Tool Co., Cincinnati, Ohio. The machine is intended for drilling and tapping work that is too large for a high-speed sensitive upright drilling machine but that requires the drilling and tapping of small holes at a much greater speed than can be obtained in a heavy-duty radial drilling machine. The rapidity with which the drill can be placed in position in the radial type of machine minimizes the time "between holes," while the high speed reduces the actual drilling time. The machine is built with either a 3- or 3½-foot arm. The dimensions mentioned in the following are for the 3-foot size, the weight of which is 2650 pounds.



Fosdick High-speed Sensitive Radial Drilling Machine

The spindle of the machine, like all other revolving members, is equipped with ball bearings. It is provided with a No. 2 Morse taper. Its vertical traverse is 8 inches, and the horizontal movement along the arm 28½ inches, the latter being actuated through a rack and spiral gear by means of a handwheel at the right. The position of the handwheel enables the operator to swing the arm and move the head simultaneously with the right hand, while the left hand is free to raise and lower the spindle, and clamp the arm. The latter may be swung completely around the

column. It is supported on both annular and thrust ball bearings on the column, which extends through to the top. The sensitive feed and quick return are operated by the lever at the right, or by the handwheel at the left.

The machine is provided with friction back-gears; this is a new feature for a machine of this type, and permits instantaneous shifting from high drilling speeds to slow speeds for tapping or for the drilling of larger holes, the ratio being 4½ to 1. The tapping attachment frictions, like those of the back-gears, are easily adjustable with an ordinary screw-driver. The drive is through tight and loose pulleys on the machine, giving both a high and a low speed, forward and reverse. The pulley guard and belt-shifter are adjustable to suit the belt at any angle. Another feature is the full contact of the belt, which maintains a uniform tension regardless of the position of the head.

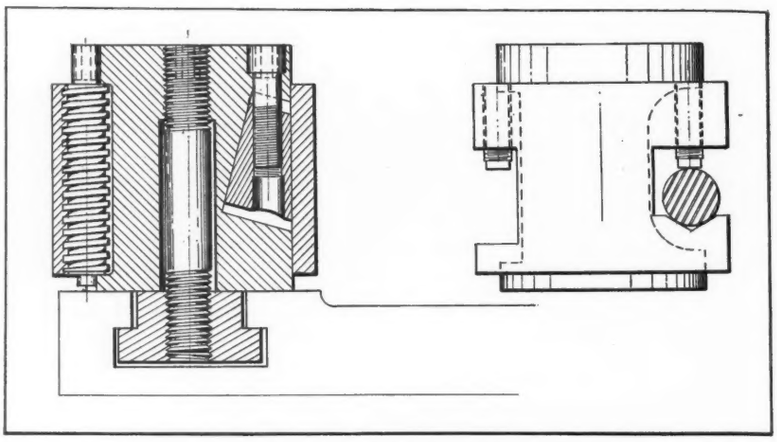


Fig. 2. Cross-sectional and End Views of Toolpost, showing Adaptability for Both Round and Square Shanks

The table is readily removed, allowing a space of 49½ inches between the spindle and the base. The base has a working surface of 28 by 36 inches, and is planed and provided with T-slots. The table can be moved vertically a distance of 16 inches, through a telescopic screw supported by ball bearings. The working surface of the table is 20

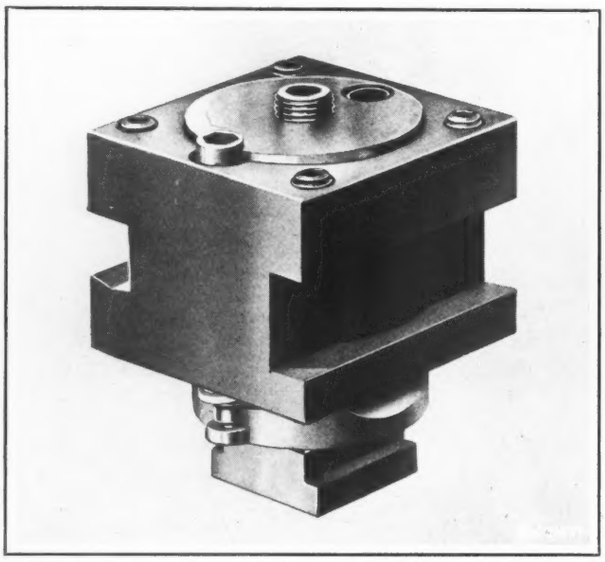


Fig. 1. Skelton Toolpost for facilitating the Raising and Lowering of Lathe Tools

by 33 inches, and its maximum distance from the spindle 31 inches. Separate box or universal tables can be furnished for use in place of the regular elevating rectangular table. When the machines are motor-driven, they require a one-horsepower motor, of either the constant or variable-speed type, as desired.

SKELTON ELEVATING TOOLPOST

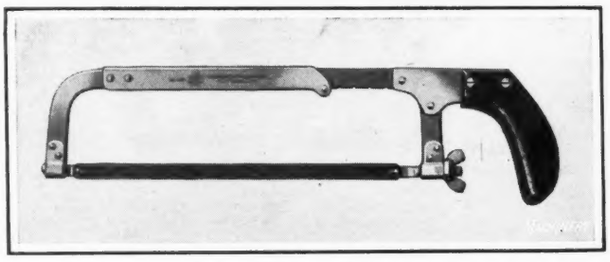
Elevating or lowering a boring-bar or other tool in a lathe without disturbing its setting otherwise can be accomplished by employing the elevating toolpost here illustrated, which is a recent product of Charles E. Skelton, 4025 S. Salina St., Syracuse, N. Y. This toolpost has a cylindrical part which is clamped to the cross-slide of the lathe by means of a stud having right-hand threads at both ends. The threads of the upper end, which engage the threads of a tapped hole in the cylindrical part, as shown in the sectional view of the toolpost, Fig. 2, are of a pitch slightly smaller than the threads of the lower end of the stud, which enters the tapped hole of the clamping plate. As both threads are right-hand, a sufficient clamping effect is obtained without using fine-pitch threads, and the required pressure can be applied with a light wrench.

A block having a recess on two sides for carrying tools, slides vertically on the fixed cylindrical part. The recess on one side is somewhat deeper than that on the opposite side, and has a V-groove for holding round-shank tools. The second recess is intended for receiving rectangular and square shanks. Raising or lowering of the tool-carrier is accomplished through an Acme-thread screw which has top and bottom bearings in the fixed cylindrical part, while its threads engage the threads of a hole at the front of the tool-carrier. When a tool has been set to the desired level, the carrier is clamped in position by means of a wedge at the back of the carrier which can be raised or lowered by turning a screw.

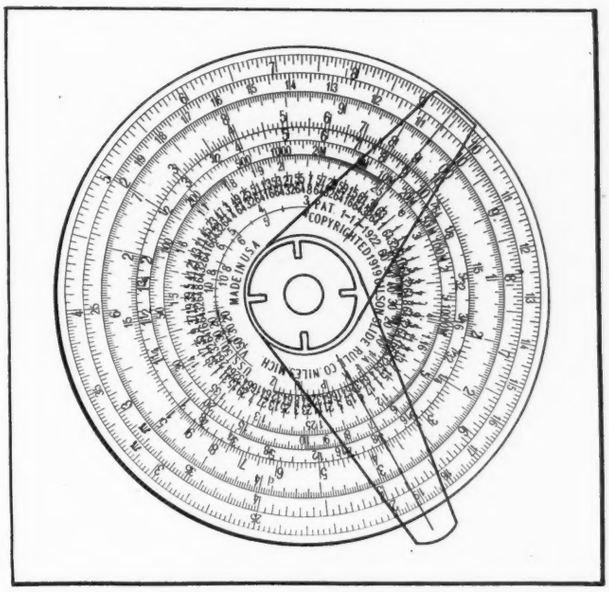
The toolpost is supplied with hollow-head screws so that nothing will project above the top to interfere with the operator's view during a boring operation. However, square-head set-screws may also be provided. All parts are made either from nickel steel and heat-treated or from carbon steel and pack-hardened. The tool-carrier will accommodate boring-bars with a 1-inch diameter shank or under, and lathe tools with shanks up to 1¼ by ⅝ inch.

CONSOLIDATED HACKSAW FRAME

An "Easy-Grip" hacksaw frame which accommodates blades from 8 to 12 inches in length has been recently placed on the market by the Consolidated Tool Works, Inc., 296 Broadway, New York City. The hard-wood handle is designed to obviate cramping of the hand and to afford an easy stroke. The blade is tightened by means of a wing-nut located at the handle end of the frame. The blades can be faced in four directions by simply changing the position of the square-section stretcher piece to which each end of the blade is attached. The notches in the under side of the adjustable part of the frame are spaced ½ inch apart, so that the frame can accommodate blades which are not of standard length.



No. 40 Consolidated "Easy-grip" Hacksaw Frame



"Midget" Circular Slide-rule which has Additional Scales to those on Ordinary Slide-rules

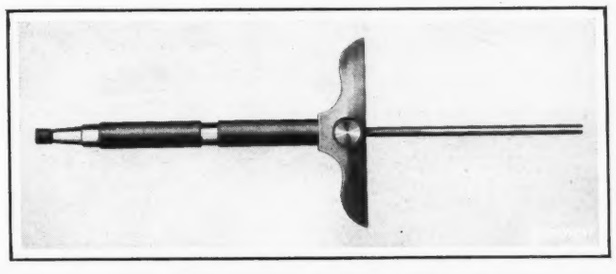
GILSON CIRCULAR CALCULATOR

A circular celluloid calculator or slide-rule which has all the scales of the ordinary slide-rule, and in addition other scales useful in many drafting-room and shop calculations, is being manufactured by the Gilson Slide Rule Co., Niles, Mich. The illustration shows that there are two transparent celluloid indicators on the face of the instrument which have hair lines for close reading. The longer indicator always gives the answer to the problem being solved. One of the interesting features is a binary scale which is divided into eighths, sixteenths, and thirty-seconds of an inch, etc. This scale makes it possible to multiply and divide fractions and mixed numbers without changing the fractions to decimals, and to read the answer as a decimal or a fraction.

Another scale permits the addition and subtraction of decimals or fractions. Also, fractions and decimals may be added or subtracted from each other and the result read as a decimal or as a fraction. Other scales give the diameter of drills from No. 1 to 60 in decimals and fractions, and the diameter of drill to use for any sized tap having from three to fifty threads per inch. The latter scale also gives the root diameter of bolts with U. S. standard or V-threads. The "Log-log" scale is a spiral, and with it any root or power can be determined, usually with but one set of the indicators. An inverted C-scale permits handling three factors at one setting, while with the A-scale square roots and corresponding powers can be obtained without the use of the "Log-log" scale. On the reverse side are graduations which give the sine, cosine, tangent, and cotangent of all angles. Another scale gives six-place decimal equivalents of fractions. This calculator is 4 inches in diameter.

STARRETT SPRING DEPTH GAGE

A new device known as a No. 48 spring depth gage, which is particularly adapted for taking quick measurements, has been brought out by the L. S. Starrett Co., Athol, Mass. A spring in the barrel automatically forces the rod downward until it is locked in position by the clamping screw shown. The gage has an especially long base—2½ inches. The base is 0.4 inch thick, and the rod is ⅛ inch in diameter. Both the base and the contact point of the rod are hardened and ground. The contact end of the rod is ground square instead of convex, to make it easier to measure from the flat surface to a very narrow shoulder. The gage is especially useful for measuring the depth of drilled holes. Its capacity is 3 inches.

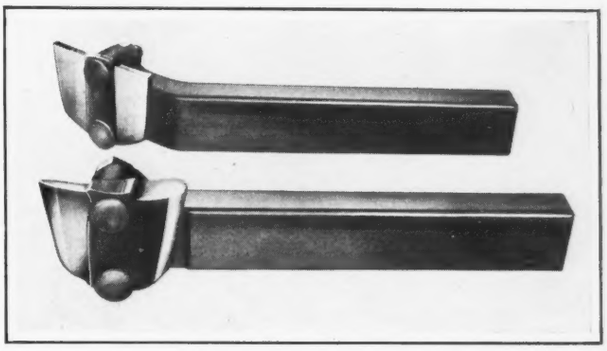


Starrett No. 48 Spring Depth Gage

MORRIS TOOL-HOLDERS AND INTERCHANGEABLE CUTTERS

A line of patented tool-holders and interchangeable cutters for taking unusually heavy cuts in lathes, planers, shapers, boring mills, and slotters is being introduced on the market by the Morris Tool Co., 30 Church St., New York City. As shown in the accompanying illustration, each tool consists of a chrome-nickel steel holder to which a heat-treated high-speed steel cutter or blade having two cutting edges is attached by means of heat-treated tool-steel bolts. The holder is made with straight and offset shanks and, as either of the two narrow sides may be used as its base, one offset shank provides for both right- and left-hand positions of the cutter.

The cutter may be clamped on either side of the holder and reversed from front to back on both sides to permit the two cutting edges to be used. A unique feature of the device is the provision for raising the plane of a cutting edge relative to the axis of the holder as the cutting edges



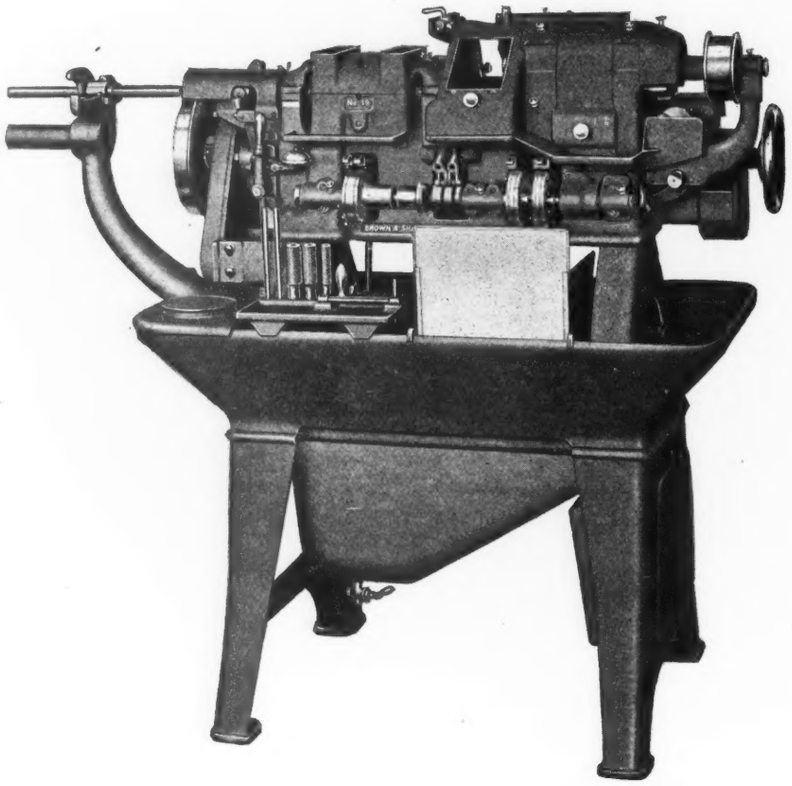
Morris Straight and Offset Tool-holders with High-speed Steel Cutter Blades

are ground away. The bolt holes are offset and so, by removing the cutter, reversing the holder relative to it, and reclamping the cutter, the cutting edges are raised. This provision permits the cutter blades to be used until ground to within ½ inch of the base line.

It is claimed that these tools are as strong and rigid as forged tools. In boring nickel-steel flasks, a cut 7/16 inch deep with a ⅛-inch feed was taken at the rate of 35 feet per minute. The bore was 20 inches in diameter and 76 inches long. Three of these flasks were machined without grinding of the cutter edge being necessary. The tools are made in twelve sizes, the smallest of which is intended for use on bench lathes.

GLUE POT WITH AUTOMATIC HEAT CONTROL

Glue is one of the important factors in the successful operation of polishing rooms and pattern shops. The experimental stations of the United States Government have established that glue possesses its greatest holding qualities at temperatures of from 140 to 150 degrees F. When heated to 175 degrees F. or more, it loses its tensile strength, and if cooled below 105 degrees, there is a decided loss in its holding qualities. Hence, thermostatic heat control has been recommended for glue pots. With the aim in view of



BROWN & SHARPE
No. 19 AUTOMATIC
SCREW MACHINE

A High-Speed Machine for Brass and Similar Work

This machine is designed primarily for work on brass. It accurately and automatically turns pieces from the bar at an extremely rapid rate.

The work spindle runs in one direction only, at either of two instantly available speeds. The turret consists of a drum revolving horizontally on an axis parallel to that of the work with sliding spindles for advancing and withdrawing the tools.

On account of its high speed the spindle is constantly lubricated and cooled by a large flow of oil which is forced to the bearings by a pump. To eliminate the effects of belt pull from the spindle the two driving pulleys are not mounted directly on the spindle, but are supported on roller bearings carried in extensions of the spindle housings.

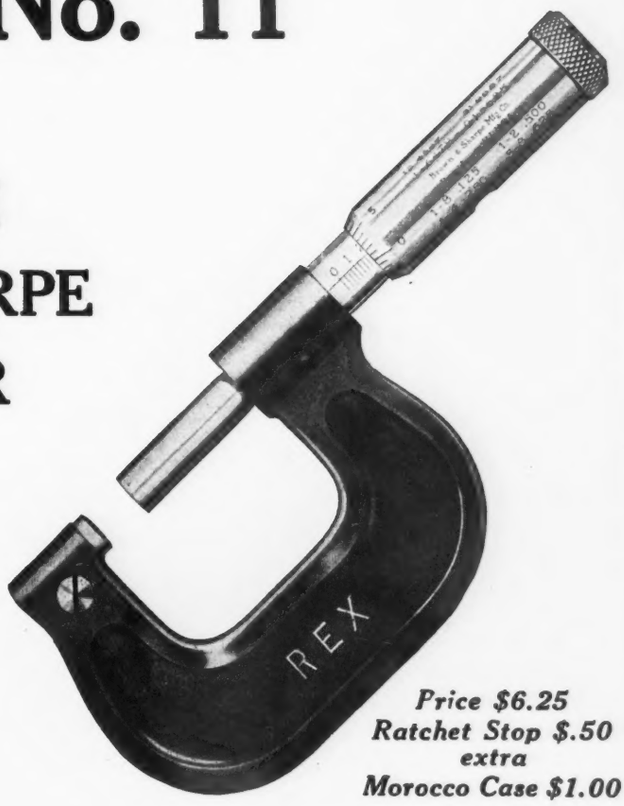
Such construction insures the accuracy essential for satisfactory automatic production at high speed. Manufacturers of brass radio parts and similar work should investigate the production possibilities of this speedy, accurate machine. Send for Specification Sheet describing this machine in detail.

BROWN & SHARPE MACHINISTS' TOOLS

REX—No. 11

A ONE INCH BROWN & SHARPE MICROMETER

At a low price



Price $6.25
Ratchet Stop $.50 extra
Morocco Case $1.00

This accurate, inexpensive measuring tool is admirably suited to the needs of screw machine operators. Its frame of I-section, combining strength with lightness, has a rectangular shape which gives larger measuring capacity than a frame of circular shape.

The screw machine operator will find constant use for this tool both in setting up work and in testing for accuracy during production. In the tool crib this micrometer will settle arguments about the size of bits, reamers, counterbores, etc. Encourage your men to use Rex Micrometers. More uniform accuracy of production will be the result.

There is a complete Rex line of micrometers in 24 sizes, covering a range from 0 to 24 in. These high grade measuring tools make available at a low price the Brown & Sharpe accuracy you have always known. Rex Micrometers will meet every measuring requirement of the busy shop. Write for our circular describing the complete Rex line.

Rex Micrometers are Brown & Sharpe Tools

BROWN & SHARPE MFG. CO.

PROVIDENCE, R. I., U. S. A.

meeting the needs of the industry for a glue pot, the heat of which can be fully controlled—that is, that will be fully automatic and require no personal attention—J. D. Wallace & Co., 1421 W. Jackson Blvd., Chicago, Ill., have brought out an electrically heated glue pot, which operates from any electric lighting circuit and is put in operation by merely turning the switch. As it is provided with an automatic heat control, it cannot become overheated, requires no attention from the workmen, and keeps the glue at the right temperature for maximum strength and viscosity. Thus spoiled work due to overheated or underheated glue is prevented.

NEW MACHINERY AND TOOLS NOTES

Pillar Punch Press: George W. Dover, Inc., 1012 Eddy St., Providence, R. I. A small pillar punch press developed primarily for work on radiator cells, although it is also adapted for any sheet-metal work within its capacity. The press is equipped with a roll feed. The ram has a stroke of 1¼ inches and a vertical adjustment of 2 inches. The maximum distance from the ram to the bed is 5 inches.

De Bats Metal No. 4: De Bats Sales, Inc., 60 South St., Boston, Mass. A non-ferrous alloy of the tungsten-chromium-cobalt class, for which remarkable claims are made in the way of speed and endurance in cutting cast iron and alloy steels. It is produced by melting in electric furnaces and casting in steel molds to the form of tool bits, inserted teeth for milling cutters, twist drills, reamers, etc. Standard sizes of tool bits are made for use with Armstrong holders. For more severe duty, blocks of the metal are welded to carbon-steel shanks.

Metal-parts Washing Machine: Crescent Washing Machine Co., New Rochelle, N. Y. A machine for washing metal parts produced in quantities of 50,000 to 100,000 per day, which is arranged for both washing and rinsing the parts as well as for drying them, when the latter is required. The machine is suitable for use in the manufacture of automobile parts, cleaning objects up to 24 inches in height, 40 inches in width, and 16 feet in length. Small objects, such as stampings and screw machine products, are placed in racks made of wire mesh to feed them through the machine. The work is first introduced into a chamber having four sets of revolving washing units which spray water on the work, and then through the rinsing chamber which has two units.

Multi-angle Sine Plate: Carling Tool & Machine Co., 302 Asylum St., Hartford, Conn. A sine plate which provides an easy means of setting work to a compound angle. Angles up to 46 degrees can be set by the use of size blocks. The pivot shafts of the device are located at exactly 90 degrees with each other and permit inclination of the table in forward and sidewise directions. The edges, table top, and base seat are accurately aligned with the pivot shafts to permit quick set-up on the table of a grinding machine. The size blocks used in setting the device to an angle are placed on the proper gaging point, after which the corresponding pivot shaft is locked. The binding action is against the size blocks and supporting walls, so that the setting is not disturbed in clamping.

* * *

DETERMINING THE DIAMETER AT THE END OF A TAPERED ROD

In September MACHINERY, page 57, a comment appeared on the article "Determining the Diameter at the End of a Tapered Rod," which was published in July MACHINERY, page 910. The formula for determining M as given in July is correct, while that published in September is incorrect. In the latter solution, the equation for N should be

$$N = T \tan a = [r - (r \tan a) \cos a] \tan a.$$

* * *

When the *St. Louis*, one of the American Line steamers, sails from New York next January, it will carry exhibits of 300 American manufactures to the West Indies, South America, Africa, Australia, Japan, China, India, Turkey, Greece, Italy, France, Spain, Portugal, Belgium, Holland, Germany, Sweden, Norway, and the United Kingdom. The purpose is to familiarize foreign markets with American-made products.

PERSONALS

H. J. SWANSON has been appointed general sales manager of the Peerless Machine Co., 1611 Racine St., Racine, Wis., manufacturer of high-speed metal saws.

W. C. ALLEN, who has been in charge of the Chicago branch of the Black & Decker Mfg. Co., Baltimore, Md., for the past year, has been appointed sales supervisor.

GEORGE SCHERR, dealer in machine tools, 126 A Liberty St., New York City, is at present in Europe on an extended business trip. He will visit Italy, Austria and Germany. His address while in Europe will be care of Schuchardt & Schutte, 29 Spandauer St., Berlin, Germany.

A. W. ROBBINS, for several years connected with the Standard Roller Bearing Co., and the Bearings Service Co., is now with the Bearings Co. of America, Lancaster, Pa. Mr. Robbins will have headquarters at the Detroit office of the company located at 1012 Ford Bldg., Detroit, Mich.

R. S. MITTEN has been appointed branch manager for the Chicago territory of the Black & Decker Mfg. Co., Baltimore, Md. Mr. Mitten was formerly sales manager of the Electric Appliance Co., of Chicago. The territory which is to be in Mr. Mitten's charge consists of the states of Illinois, Iowa, Wisconsin, Minnesota, North Dakota, the eastern half of Missouri, including St. Louis, a small corner of Indiana, taking in South Bend, and the western end of the state of Michigan.

ROBERT C. YATES, for many years connected with the Union Drop Forge Co., Chicago, Ill., has left that company to become general manager of the Interstate Drop Forge Co. of Milwaukee, Wis., which was organized in 1919 for the manufacture of small commercial forgings, and which is closely allied with the Chain Belt Co., the Sivyer Steel Casting Co., and the Federal Malleable Co., all of Milwaukee. Mr. Yates, after graduating from Union College, Schenectady, N. Y., was connected with the American Locomotive Co. and later with the Bethlehem Steel Co. He was manager of the Chicago district office of the Bethlehem Steel Co. prior to his connection with the Union Drop Forge Co.

* * *

STEEL TREATING AND DROP-FORGING CONVENTIONS

The Drop Forge Supply Association has made arrangements for holding a meeting of its members in Detroit at the same time as the American Society for Steel Treating and the American Drop Forging Institute will hold their conventions, October 2 to 7. The meeting of the Drop Forge Supply Association will be held October 3, at 12:30, in the General Motors Building.

The Committee on Steel of the American Society for Testing Materials will also meet in Detroit in connection with the International Steel Exposition and the conventions of the two societies mentioned. This committee will meet on October 5 and 6 at Hotel Statler, meetings being held during the first day at 10:00 A. M. and 2:00 P. M., and on the second day at 10:00 A. M.

One of the most interesting events in connection with the exposition and the convention of the American Society for Steel Treating will be the unveiling of a bronze tablet dedicated to the memory of those pioneers in the steel industry who in 1864, at Wyandotte, Mich., erected the first Bessemer steel converter used commercially for the manufacture of Bessemer steel in America. This tablet is to be erected by the Detroit chapter of the American Society for Steel Treating. The site of the Wyandotte Iron Works where the first tilting Bessemer steel converter was erected is the present location of the Wyandotte public library, and the tablet will be placed in the front of this building. The unveiling exercises will be held on Thursday afternoon, October 5.

* * *

FITCHBURG INDUSTRIAL EXPOSITION

The diversified industries of Fitchburg, Mass., were exhibited at a manufacturers' and merchants' exposition held in the State Armory on September 18 to 22. Among the exhibitors in the metal-working field were the following: Fitchburg Machine Co., Putnam Machine Co., Simonds Mfg. Co., Universal Grinding Machine Co., and Fitchburg Grinding Machine Co.

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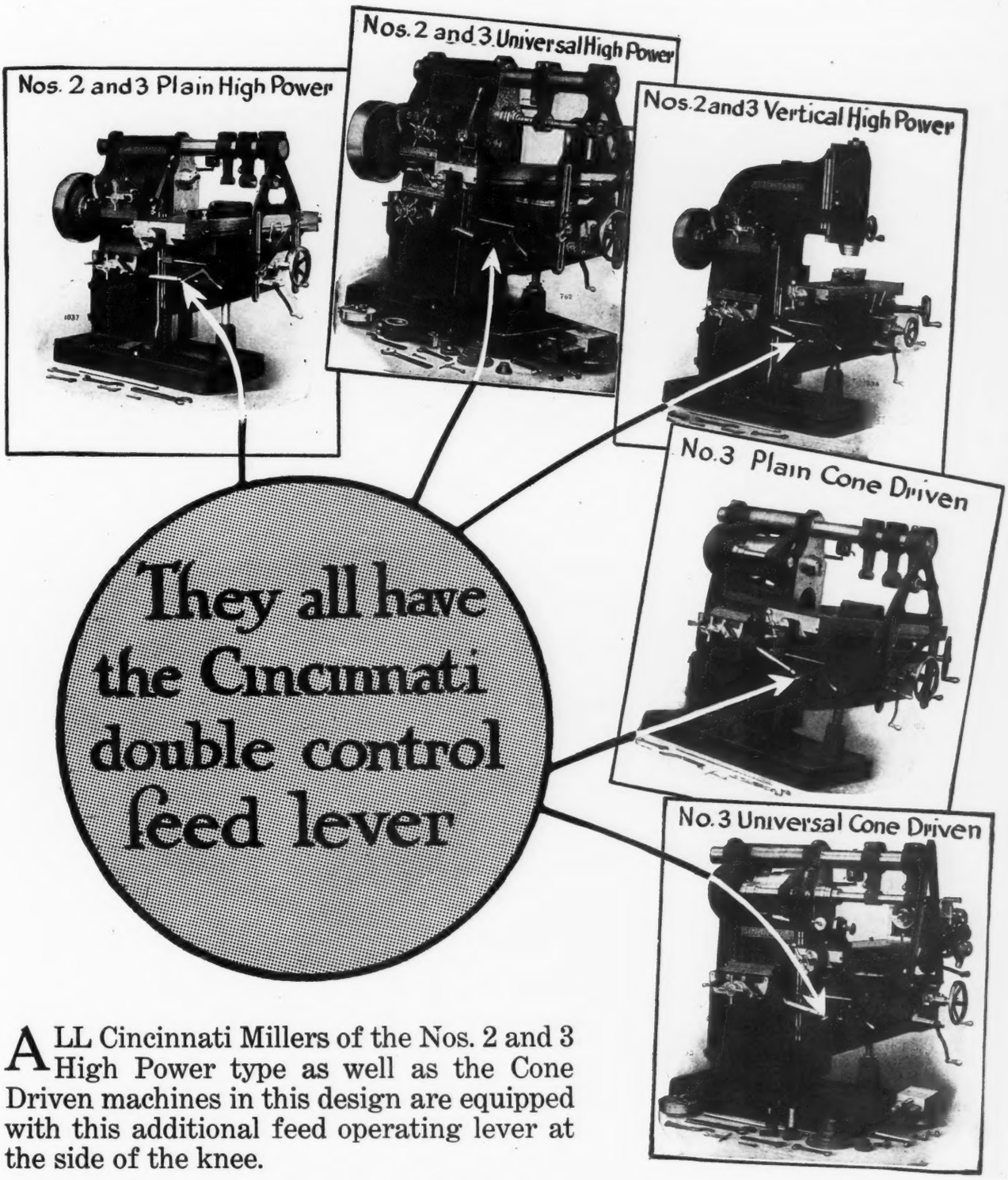
The index to the twenty-eighth volume of MACHINERY (September, 1921 to August 1922, inclusive) is ready for distribution. Copies will be sent upon request.


Nos. 2 and 3 Plain High Power
Nos. 2 and 3 Universal High Power
Nos. 2 and 3 Vertical High Power
No. 3 Plain Cone Driven
No. 3 Universal Cone Driven
They all have the Cincinnati double control feed lever

ALL Cincinnati Millers of the Nos. 2 and 3 High Power type as well as the Cone Driven machines in this design are equipped with this additional feed operating lever at the side of the knee.

Whether the operator stands in the usual position in front of the machine, or behind the table as the nature of the work sometimes requires, he still has instant control over feeds.

This is only one of their many features providing unusual convenience of control.

Cincinnati reputation is founded largely upon the performance of these machines. Their great power, with convenience of control, has made them famous. We are ready with the full details.

The Cincinnati Milling Machine Co., Cincinnati, O.

TRADE NOTES

MORSE CHAIN CO., Ithaca, N. Y., manufacturer of chain drives, has removed its Philadelphia office into larger quarters. The present address is Room 612, Franklin Trust Bldg., 18-22 S. 15th St.

ILLINOIS TOOL WORKS, 154 E. Erie St., Chicago, Ill., manufacturers and designers of cutters, hobs, and reamers, have appointed the Commercial Steel & Supply Co., Plymouth Bldg., Cleveland, Ohio, as their representative in the Cleveland district.

CHAS. EISLER, mechanical engineer, Newark, N. J., has moved his factory and offices from 15 Kirk Alley to 756 S. 13th St., where he will occupy a well equipped factory of 6000 square feet floor space in a modern brick building recently erected at a cost of $30,000.

LANDIS TOOL CO., Waynesboro, Pa., manufacturer of cylindrical grinding machines, announces that, owing to increased cost of production it has been found necessary to advance the prices 10 per cent on all machines and machine parts. These prices became effective August 15.

WHITE CO. and WHITE MOTOR CO., Cleveland, Ohio, have removed their general offices from 6611 Euclid Ave. to the administration building, at the factory, St. Clair Ave. and E. 79th St., Cleveland. The Cleveland branch of the White Co. retains its present location at 407 Rockwell Ave.

CHICAGO FLEXIBLE SHAFT CO., 1154 S. Central Ave., Chicago, Ill., has opened a new district sales office at 305 Merchants Bank Bldg., Indianapolis, Ind., for handling furnace sales and Stewart engineering service in southern Indiana, southern Ohio, and western West Virginia. F. W. Odemar is in charge of the office.

ATLANTIC ELEVATOR CO. and the ALBRO-CLEM ELEVATOR CO. have consolidated. The new company will continue its business under the name of the Atlantic Elevator Co., Erie Ave. and D St., Philadelphia, succeeding to all liabilities and assets and all contracts entered into by the former companies.

GOULD & EBERHARDT, Newark, N. J., manufacturers of shapers and gear- and rack-cutting machinery, announce that the price of the shapers manufactured by the company has been increased on an average of from 15 to 20 per cent on account of the changed industrial conditions. The new price went into effect September 1.

BUOL MACHINE WORKS, 168 Arch St., New Britain, Conn., have been organized for general and special machine building, and for doing all classes of special machine work. The proprietor, Abraham Buol, was connected with the New Britain Machine Co., for about twenty-seven years, rising to the position of superintendent and vice-president.

HOFFMAN DRAWING STAND CO., formerly located at 187 N. Water St., Rochester, N. Y. has removed its plant and office to 281 Meigs St., Rochester, N. Y., a building of modern construction which the company has purchased. New manufacturing equipment is being added, which will enable the company to perform all its machine work in its own plant.

W. A. JONES FOUNDRY & MACHINE CO., manufacturer of speed-reducers and power-transmitting machinery, with general offices and factories at 4409 W. Roosevelt Road, Chicago, Ill., has opened a branch sales and engineering office at 2482 University Ave., St. Paul, Minn. C. F. Ford, who is in charge of the new branch, is an experienced transmission engineer.

MEHL MACHINE TOOL & DIE CO., 547 E. First Ave., Roselle, N. J., designer and builder of jigs, fixtures, dies, gages, and special machines, has just opened an engineering branch in Cleveland, Ohio, in order to keep in closer touch with the company's increasing number of customers in the middle-western states, and give better service in tool engineering to the middle-western manufacturing area.

B. C. AMES CO., Waltham, Mass., has acquired a substantial interest in the TRIPLEX MACHINE TOOL CORPORATION of New York City, and the Triplex combination lathe, milling machine, and drilling machine is now being manufactured in the B. C. Ames Co.'s plant at Waltham. The general office and showroom of the Triplex Machine Tool Corporation will continue to be located at 18 E. 41st St., New York City.

DIAMOND CHAIN & MFG. CO., Indianapolis, Ind., announces the opening of an office at 340 Leader-News Bldg., Cleveland, Ohio, which will be in charge of H. I. Markey, who has been with the company for five years as mechanical engineer in the engineering and sales departments. Through the Cleveland office the company will be able to be of greater service to manufacturers, engineers, and chain users in the territory including Cleveland, Rochester, and Pittsburg.

MACKINTOSH-HEMPHILL CO., Pittsburg, Pa., has acquired the property, assets and good will of the following corporations: A. Garrison Foundry Co., S. 9th and Bingham Sts., Pittsburg, Pa.; Pittsburg Iron & Steel Foundries Co., Midland, Pa.; and the Woodard Machine Co., Wooster, Ohio. These will hereafter be known, respectively, as the Garrison Plant, Midland Plant and Woodard Plant, of the Mackintosh-Hemphill Co.

REEVES PULLEY CO., Columbus, Ind., has made a change in the agency for the Reeves variable-speed transmission for the New England territory. This transmission is now sold exclusively by Manning, Maxwell & Moore, Inc., 99 Chauncy St., Boston, Mass., where a complete variable speed department has been installed, in charge of competent engineers, and where a large stock of complete transmissions and parts is carried.

C. F. DAVIS MACHINE CO., INC., formerly located at 133 Andrews St., Rochester, N. Y., moved October 1 to a new factory at 150-160 N. Water St., Rochester. The new Davis factory occupies the second floor of a modern fireproof brick and steel structure. In the new and enlarged plant a considerable amount of new equipment will be installed, making it possible to increase the output of keyseaters and keyseating cutters and to give quicker service to the company's customers.

MELDRUM-GABRIELSON CORPORATION, Syracuse, N. Y., manufacturer of Syracuse adjustable limit snap gages, has appointed W. R. Wyatt, 50 Church St., New York City, exclusive representative in the Metropolitan district and vicinity. Wm. Battersby, 3325 N. 21st St., Philadelphia, Pa., has been appointed exclusive representative of the company for southeastern Pennsylvania and Delaware. The Kemp Machinery Co., 215 N. Calvert St., Baltimore, Md., will represent the company exclusively in Maryland, Virginia, and the District of Columbia.

E. L. ESSLEY MACHINERY CO., 551-557 Washington Blvd., Chicago, Ill., has added the following men to its sales force: H A. Bruce, who will represent the company in the Michigan territory; C. B. Burns and T. P. Nielsen, who will represent the company in Chicago; and Ralph Wirth, who will be identified with the company's sheet-metal machinery department. Mr. Bruce was formerly connected with the Packard Motor Car Co., Mr. Burns with the Fairbanks Co., and Mr. Wirth with the Toledo Machine & Tool Co., and the Niagara Machine Tool Works.

OILGEAR CO., Milwaukee, Wis., has opened a New York office at 39 Cortlandt St., in order to be in direct touch with the entire eastern territory. Russell, Holbrook & Henderson, 30 Church St., New York City, have been appointed sales representatives of this company for the district in and near New York City. The Cadillac Machinery Co., 452 E. Lafayette St., Detroit, will handle Oilgear products in the state of Michigan, and R. E. Ellis Engineering Co., 621 Washington Blvd., Chicago, will represent the Oilgear Co. in Chicago and the surrounding district.

HUNTER SAW & MACHINE CO., 57th and Butler Sts., Pittsburg, Pa., manufacturer of metal-cutting circular saw blades, saw-sharpening machines and hardened steel specialties, has opened an office in the Manhattan Bldg., Chicago, Ill., of which Paul W. Wendt is in charge. A complete stock of metal-cutting saw blades, pneumatic hammer rivet sets, and chisel blanks will be maintained there. The company has also opened an office at 56 Pine St., New York City, in charge of Frank E. Harrison, and a complete stock of the company's products will also be carried by this office.

ALFRED BOX & CO., Philadelphia, Pa., manufacturers of electric cranes and hoists, have disposed of their old factory on Front St., and will soon move into a newly erected plant at Ontario St. and Trenton Ave., Philadelphia. The new plant will have a main bay in the middle, 50 by 240 feet, and two side bays, 30 by 240 feet. The main bay is 50 feet high. A separate building, 30 by 90 feet, will be used for pattern shop and storage. The building will contain five electric cranes, and all the machine tools will be motor-driven. The capacity of the new plant will be three times that of the old.

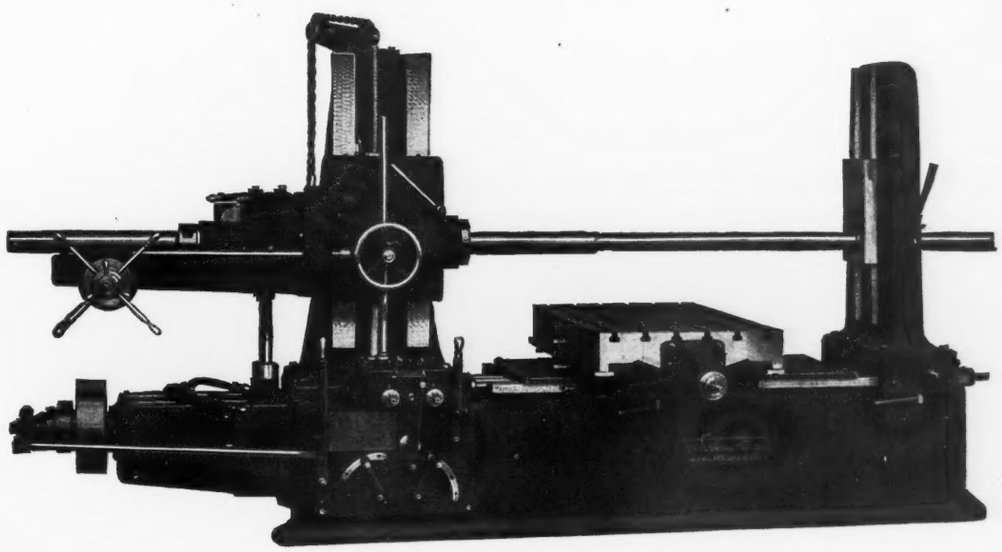
DAVIS BORING TOOL CO., INC., St. Louis, Mo., manufacturer of expansion boring tools and expansion reamers, has purchased a factory site on Forest Park Blvd., at the corner of Spring Ave., St. Louis. Preliminary work is now under way for the erection of a modern three-story factory building. During the last eighteen years the company has outgrown four different buildings, the rapidly increasing demand for the company's product having necessitated several increases in floor space from time to time. The present factory is now inadequate for the requirements. The new site provides for additional expansion in the future.

CONSERVATIVES like the

"PRECISION"

Boring, Drilling and Milling Machine

Because It Is *Reliable*



PROGRESSIVES

like it because it is *Efficient*

WE like it because we believe that in it we are furnishing the world with something to its advantage.

LUCAS MACHINE TOOL CO. NOW AND ALWAYS OF **CLEVELAND, OHIO, U.S.A.**

FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry. Societe Anonyme Belge, Alfred Herbert, Brussels. Aux Forges de Vulcain, Paris. Allied Machinery Co., Turin, Barcelona, Zurich. Benson Bros., Sydney, Melbourne. V. Lowener, Copenhagen, Christiania, Stockholm. R. S. Stokvis & Zonen, Rotterdam. Andrews & George Co., Tokyo.

COMING EVENTS

October 2-7—Annual convention and exposition of the American Society for Steel Treating in Detroit, Mich., General Motors Bldg. Secretary, W. H. Eisenman, 4600 Prospect Ave., Cleveland, Ohio.

October 18-20—Ninth national convention of the Society of Industrial Engineers at Hotel McAlpin, New York City. Office of the secretary, 327 S. LaSalle St., Chicago, Ill.

October 25-27—Third annual meeting of the American Trade Association Executives at the Inn, Buckhill Falls, Pa.

October 26-27—Automotive production meeting of the Society of Automotive Engineers to be held in Detroit. Further information may be obtained from the Society of Automotive Engineers, 29 W. 39th St., New York City.

December 4-7—Annual convention of the American Society of Mechanical Engineers, in the Engineering Societies Bldg., 29 W. 39th St., New York City. Calvin W. Rice, secretary.

December 7-13—National Exposition of Power and Mechanical Engineering at the Grand Central Palace, New York City. Charles F. Roth, manager, Grand Central Palace, 46th St. and Lexington Ave., New York City.

March 18-24, 1923—Second general meeting of the International Chamber of Commerce in Rome, Italy. Lacey C. Zapf, secretary American Section, Mills Bldg., Washington, D. C.

NEW BOOKS AND PAMPHLETS

Proceedings of the National Association of Office Managers, Third National Conference, Washington, D. C., May 18 to 20, 1922. 73 pages, 8½ by 11 inches. Published by G. S. Childs, secretary of the association, Alexander Hamilton Institute, 13 Astor Place, New York City. Price, $1.50.

Knots, Splices, and Rope Work. By A. Hyatt Verrill. 104 pages 4¼ by 6½ inches; 154 illustrations. Published by the Norman W. Henley Publishing Co., 2 W. 45th St., New York City. Price, $1.

This is the third revised edition of a book that gives complete and simple directions for making the most useful knots commonly employed. It includes chapters on splicing, pointing, seizing, serving, etc., and is intended for the use of all who employ or handle ropes for any purpose.

Jigs, Tools, and Fixtures. By Philip Gates. 195 pages, 4½ by 7½ inches; 165 illustrations. Published by the D. Van Nostrand Co., 8 Warren St., New York City. Price, $2.50.

This book, which is prepared by an English author, deals with equipment for various types of machine tools. Chapters on the first principles of mechanical drawing and sketching are included, which are followed by chapters on drill jigs, milling fixtures, chucks, cutters, threading tools, gages, press tools, and tool designing procedure.

Maxton's Manual of Engineering Drawing. By John Maxton and G. C. Malden. 251 pages, 4½ by 7½ inches; 313 illustrations. Published by the D. Van Nostrand Co., 8 Warren St., New York City. Price, $3.

This is a new edition of Maxton's Manual, a work of English origin, the new edition having been revised and some new material added by Lieutenant-Commander G. C. Malden of the British Navy. The book covers the subject of mechanical drawing in a conventional way. The new matter that has been added deals specifically with the laying out of propellers.

Modern Work-shop Practice. By Ernest Pull. 671 pages, 5¼ by 8¼ inches; 542 illustrations. Published by the D. Van Nostrand Co., 8 Warren St., New York City. Price, $5.

This book, compiled and prepared by an English author as a text-book, covers briefly a great number of subjects relating to machine shop practice. The present edition, which is the sixth, has been rewritten and considerably enlarged. The chapter on measuring tools and measuring machines, for example, includes descriptions of some of the very accurate measuring machines recently introduced by British manufacturers. Gaging and gaging systems have been referred to in greater detail than in the past, and a number of the other chapters have been enlarged.

Machinists' and Draftsmen's Handbook. By Peder Lobben. 487 pages, 4½ by 7½ inches. Published by the D. Van Nostrand Co., 8 Warren St., New York City. Price, $3.

This is the third edition of Lobben's Handbook. The first edition appeared in 1899, and was republished in 1910 in a second edition, which was considerably enlarged. In the present edition a few of the tables in the steam section have been revised and the electrical formulas have been made to conform to the new standardization rules. The book deals with arithmetic, algebra, logarithms, weights and measures, geometry, strength of materials, mechanics, mechanical power transmission, screws, pipes, hydraulics, steam, and electric terms, and contains a few shop notes and directions for blueprinting.

Engines and Boilers. By Thomas T. Eyre, 234 pages, 5½ by 8½ inches. Published by the MacMillan Co., 64 Fifth Ave., New York City. Price, $3.50.

This is a text-book on engines and boilers which is intended for use in engineering schools that offer an elementary course in heat engines. No attempt has been made in this book to cover the more advanced work in thermodynamics or to give an exhaustive treatment of the subject of heat power. The author is dean of the College of Engineering of the State University of New Mexico, and was formerly assistant professor of mechanical engineering at Purdue University, and his work is the result of experience gained in teaching classes in engines and boilers and in allied subjects at Purdue University. The material is divided into eleven chapters dealing with the following subjects: Pressure, Temperature, and Heat Units; Fuel; Steam; Boilers; Boiler Accessories and Auxiliaries; the Steam Engine: Common Types of Steam Engines; Valves; Governors; Steam Turbines; and Gas Engines.

NEW CATALOGUES AND CIRCULARS

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Catalogue 6-M, entitled "Westinghouse Line Material for Mines."

Electric Controller & Mfg. Co., Cleveland, Ohio. Circular entitled "A New Motor," illustrating the features of the Type NC squirrel-cage induction motor made by this concern.

Hobart Bros. Co., Troy, Ohio. Folder entitled "HB Constant Potential Battery Charger," describing the new and improved battery charging equipment built by the company.

Sprague Electric Works of General Electric Co., 627 W. 34th St., New York City. Bulletin 68912, illustrating and describing Sprague electric Type WX worm drive hoists.

New Departure Mfg. Co., Bristol, Conn. Loose-leaf sheets Nos. 147FE and 148FE, illustrating the application of ball bearings in motor-generator sets and induction motors.

Roller-Smith Co., 233 Broadway, New York City. Bulletin 250, illustrating and describing the company's portable direct-current galvanometers known as Types LGD and KGD.

Pawling & Harnischfeger Co., Milwaukee, Wis. Bulletin 3-T, illustrating and describing the No. 3-T table type horizontal boring, drilling, and milling machine, built by this company.

General Electric Co., Schenectady, N. Y. Bulletin 47606, entitled "Relays," dealing with the operation and general application of relays. Bulletin 44015, entitled "Safety Car Equipment."

Bausch & Lomb Optical Co., Rochester, N. Y. Booklet entitled "What Lens Shall I Buy?" This publication includes both a complete catalogue of lenses and a compendium of lens applications.

Bristol Co., Waterbury, Conn. Catalogue 1401, of Bristol pyrometers. This catalogue consists of 68 pages, is profusely illustrated, and contains much valuable information on the subject of pyrometers.

Schutte & Koerting Co., Philadelphia, Pa. Bulletin 8 G, illustrating and describing Schutte regrinding swing gate valve, designed for steam pressures up to 300 pounds per square inch and temperatures up to 750 degrees F.

Cleveland Engineering Institute, 8120 Euclid Ave., Cleveland, Ohio. Booklet entitled "The School of Greater Opportunities," describing the courses given in this institute, which specializes in teaching heating and ventilating engineering.

Precision & Thread Grinder Mfg. Co., 1 S. 21st St., Philadelphia, Pa. Folder illustrating and describing the company's multi-graduated precision grinder, precision thread lead variator, and permanent alignment wheel-truing head. A partial list of the users of the company's products is also given.

Ingersoll Milling Machine Co., Rockford, Ill. Folder illustrating and describing the milling of impeller bodies for blowers, as it is being done in one of the largest blower shops in the country on Ingersoll milling machines to an accuracy of plus or minus 0.003 inch over the entire form of the impeller body.

Whiting Corporation, Harvey, Ill. Catalogues 161 to 164, illustrating and describing, respectively, ladles, tumbling mills, core oven equipment, and trucks and turntables. Each of these catalogues is profusely illustrated, showing not only detail pictures of the equipment but also illustrations of installations.

Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Folder illustrating and describing the Shepard electric "Liftabout," a small electric hoist designed for the smaller load-moving and lifting jobs, such as three, four or five men are ordinarily able to do. This hoist is made in capacities up to 2000 pounds.

Wiesman Mfg. Co., 14 N. Canal St., Dayton, Ohio. Circular of Wiesman safety guard for punch presses, illustrating and describing the improved type of Wiesman safety guard. The circular also gives instructions for ordering these safety guards, specifying what data should be given in order that the right type of guard may be supplied.

Winfield H. Smith, 10-16 Lock St., Buffalo, N. Y., Catalogue 20, descriptive of a full line of power transmission machinery, including grooved iron pulleys, crown faced pulleys, hangers, pillow blocks, reducing gears, etc. Data are also given for arbor presses, and revolving display tables. Dimensions and price lists are given.

Willson Goggles, Inc., Reading, Pa. Folder illustrating and describing Willson respirators for dusty work. Price list of safety goggles and respirators for dusty work. Folder illustrating and describing helmets and hand-shields for electric welding. Catalogue illustrating and describing the different types of safety goggles manufactured by the company.

Midwest Steel & Supply Co., Inc., 28 W. 44th St., New York City. Folder illustrating and describing the Midwest transmission steel sections for anchoring shaft hangers, cables, and piping, and for fastening sprinklers and lighting and similar equipment. These transmission steel sections are made in what is known as "box" rail, "L" rail and steel stringer sections.

Reeves Pulley Co., Columbus, Ind. Booklet entitled "Engineer's Manual," listing the complete line of variable-speed transmissions built by the company, pointing out their various uses, and giving mechanical data pertaining to them. The company has also brought out a catalogue entitled "Reeves Wood Split Pulleys," describing and illustrating this type of pulley and showing illustrations of its application.

Electric Furnace Co., Salem, Ohio. Circular illustrating and describing Baily electric furnaces for melting non-ferrous metals, calling attention to what alloys they are melting, what products they are producing and what the users think of them. Also circular of some of the many types of electric enameling, annealing, and heat-treating furnaces that have been installed by the company during recent years.

B. F. Sturtevant Co., Hyde Park, Boston, Mass. Engineering bulletin dealing with pneumatic collecting and conveying. This bulletin of 72 pages contains 33 pages of pictures and diagrams, and 17 pages of tables, indicating how to find the size of fans, the suction, volume, revolutions per minute, and horsepower for any system, cubic feet of air handled per minute, and size of pipes and ducts used, together with a great deal of other useful data.

Mehl Machine Tool & Die Co., 547 E. First Ave., Roselle, N. J. Catalogue entitled "Tool Service," illustrating by interior views of the company's shops the facilities that the company has for doing special tool work. It deals specifically with the work being done in the design and making of jigs, fixtures, dies, gages, and special machines, and illustrates some of the equipment that has been built by the company. Illustrations and descriptions of the designing department, pattern shop, and inspection department of the company complete the catalogue.

Jacobs Mfg. Co., Hartford, Conn. Booklet entitled "The Backbone of Automotive Service." The object of the booklet is to promote a more general appreciation of the importance of adequate shop equipment in automotive service stations and repair shops. It makes a strong point of the fact that adequate machine tool equipment is a necessity for profitable work in this field, and then refers specifically to some of the essential machine tools in the service plant—the lathe, drilling machine, portable electric drill, cylindrical grinding machine, cylinder grinder, and arbor press.

Lovejoy Tool Co., Inc., Springfield, Vt. Catalogue of positively locked inserted-tooth milling cutters, illustrating and describing the various classes of milling cutters manufactured by the company, including face milling cutters from 6½ to 18 inches in diameter; side milling cutters, from 6 to 14 inches in diameter; plain milling cutters, from 6 to 16 inches in diameter; and plain arbor mills from 4½ to 12 inches in diameter. In addition, the catalogue illustrates and describes staggered-tooth grooving mills, deep slotting cutters, stellite blades, taper shank arbors, and multiple cutter boring heads.

Chambersburg Engineering Co., Chambersburg, Pa. Bulletin 67, illustrating and describing the company's steam drop-hammers, one of the special features of which is that they have parallel adjustable type guides with large vees, providing a large wearing surface. The guides can be removed without removing the ram. As the lower portions of the guides are subjected to the greatest wear, upper and lower horizontal adjusting shoes are provided, which are regulated from the side of the hammer for adjusting the guides very accurately, as is required in matched die work. These shoes can be removed without disturbing the guides.

A. W. Cadman Mfg. Co., Pittsburg, Pa. Engineering bulletins M-1 and M-2, containing technical data on bearing metals obtained from actual tests. The information contained in Bulletin M-1 includes requirements of a bearing metal and properties of Cadman metals—hardness and compressive strength, relative wear, coefficient of friction, ability to hold an oil film under adverse conditions, plasticity, heat conductivity, uniformity, and tensile strength and bonding properties. Bulletin M-2 treats of types of bearing metals, requirements of a bearing metal, alloys and the theory of bearing metals, friction in bearings, and permissible bearing pressures.